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AMERICAN STEAM SNOW PLOWS IN GERMANY.

ALMOST every new and useful American invention is now taken up and introduced in Europe as quickly as possible, the usual method being to suppress its American origin and christen it with some new appellation. The accompanying engraving, for which we are indebted to the Illustrirte Zeitung, shows an example called in Germany the Gorlitz steam snow plow; but it is merely a modification of the American invention known as the Leslie plow, which for the past few years has been made at Paterson, N. J. All the leading American railways are supplied with it. The engraving shows the scene presented during the trial given to the plow at Mahlow, a station on the Imperial Military Railroad, near Berlin. This plow is arranged on an eight-wheeled car and consists of a horizontal driving shaft 9 inches in diameter, on the front end of which is a cutting wheel 9 feet 6 inches in diameter, and provided with twelve cutting blades. The other end of the shaft is connected with an engine located in the car and capable of generating 800 horse power and of revolving the plow with a load of 120 to 220 tons in a minute. This cutting wheel is inclosed in a drum casing open at the front end and so arranged that the snow can be thrown to the right or left and to a distance of 300 feet from the track. The steam necessary for driving the engine is supplied by the locomotive behind it, from which it is carried through an extensible pipe connection. A second locomotive is required for pushing, and behind this follows a train that consists of a locomotive, freight cars and from four to six passenger cars, so that the whole train is made up of three locomotives and the freight and passenger cars.

An artificial snow drift was made, that was from 3 feet to 11 feet high, the snow at the top being mixed with stones and pieces of ice forming a mass much heavier than anything likely to be encountered by a snow plow. This was cleared away very quickly. On the second day, when the train hands understood their work a little better, a drift 1,386 feet long and 11 feet high was removed in less than eight minutes, showing that with this snow plow any train could be drawn to its destination, even through the deepest snow drifts, nearly on schedule time. Two of these snow plows have been used, with the best results, by the Imperial State Railroads of Hungary.

THE LESLIE STEAM SNOW PLOW IN GERMANY—A TRIAL OF THE PLOW NEAR BERLIN.

EXPERIMENTS IN NAVIGATION WITH A COMPRESSED GAS MOTOR.

SINCE the rendering of gas motors is much superior to that of steam ones, it is much better to utilize the heat of the fuel in the cylinder of a gas motor than under a steam generator. It is therefore not surprising that attention should have been paid to the realizing of motors more economical than the classic steam engine for navigation.

Liquid fuels have already permitted of the complete substitution of internal combustion motors for the steam engine for pleasure craft and boats whose propulsion requires but a feeble motive power. But the power of gas motors increasing without limit, it is quite natural that specialists should have endeavored to utilize the progress made in this line; and we shall now present to our readers a new installation in which a 40 horse power gas motor has, for the first time, actuated a barge of respectable proportions.

The gas employed in this new motor is ordinary city gas stored up in a series of steel tubes at a pressure of about one hundred kilogrammes per square centimeter. The idea of using highly compressed gas for supplying gas motors is not new, as Messrs. Delamare-Deboutteville and Malandin themselves, as long ago as 1883-1884, constructed a tricycle that operated with gas compressed to ten kilogrammes per square centimeter in two copper cylinders; but the new application is of great interest, in that it extends the question toward a vaster field that permits of reaching much greater powers.

Mr. Capelle, a manufacturer of Havre, has, through his initiative, permitted of carrying out this new experiment by organizing in that city a company called the Seine Maritime, designed to carry on a transportation service between Havre, Rouen and Paris. The object of this combination was to build a certain number of barges, each provided with its own motor and capable of making the trip within a period of time sensibly shorter than that now necessary with steam tugs.

The gas, which is stored in steel tubes arranged in a battery upon the deck, flows to the motor after being expanded to the proper pressure in a special apparatus, which is very sensitive and very sure in its operation. A gas works, situated midway between Havre and Paris, is to assure the fuel supply of the barges. To this effect, a motor that actuates a series of compressors will permit of raising the gas to a pressure of 100 kilogrammes per square centimeter in special reservoirs. A simple pipe will connect these reservoirs with the barges when they land to renew their supply of gas.

The slight incumbrance of the motive force on board, which is reduced to the engine, after the suppression of boilers and coal bunkers, permits, moreover, of gaining a very wide space, which is devoted to merchandise alone.

The Lighter.—The first boat used for the preliminary experiments was constructed at the Mallard shipyard at Rouen. It is entirely of iron. Its length is 30 meters, its width 5·5 and its depth 2·25. Its form is that of a decked lighter with straight stem and curved stern. The stern post is of forged iron. The boat is divided into three watertight compartments. In front are the crew's quarters and the captain's cabin. Then comes a hold, followed by another of the same dimensions, the two together occupying four-fifths of the boat. Finally, comes the engine room. The gross tonnage of the boat is 300 tons. By reason of the small amount of space occupied by the motor, the crew's quarters and the captain's cabin, it may be estimated that the net gage of the boat, when loaded, will reach 250 tons. A rudder, with wide cheek and reversed tiller, is actuated through chains by a wheel maneuvered by the pilot. An English system of block chocking has been adopted, by means of which the position of the tiller is maintained on one side without

the pilot being obliged to exert a stress upon the wheel.

The Steel Tubes.—The tubes containing the supply of gas are forged in a single piece. They are 250 millimeters in external diameter, 8 millimeters in thickness, and 5 meters in length. The weight of each of them is 325 kilogrammes, and their capacity is 22 cubic meters at a pressure of 100 kilogrammes per square centimeter. They have been tested to 160 kilogrammes per square centimeter, as required by law. They are placed in battery upon the deck of the boat, in the first place in order to save space, and in the second to prevent accidents in case of a leakage of one of the tubes. In this way, should a leakage occur, the gas would escape into the open air without any other damage than a loss of a part of it. These tubes, 80 in number, are connected with each other by flexible joints like those employed by the companies that sell compressed oxygen in the United States and England.

The Motor.—The engine, which is constructed according to the Simplex type of Messrs. Edward Delamare-Deboutteville and Leo Malandin, has been entirely remodeled by these inventors in view of the new application that was to be made. This new engine, as well as the screw with reversible pitch of the MacGlasson system, was constructed by the Simplex establishment of Mattu & Co., of Rouen. The motor, which is of the upright two cylinder type (Fig. 2), directly actuates the shaft of the screw by means of two cranks keyed at ninety degrees. This arrangement permits of balancing the engine perfectly without having recourse to auxiliary counterpoises. Upon one of the extremities of this shaft there is a hand wheel that serves for setting it in motion, and upon the other a flexible gearing that permits of rendering the screw independent of the motor. This main shaft actuates an intermediate one that is parallel with it and carries the escapement cams as well as the control of the distribution, which is provided with particular regulators that permit of the regulation whatever be the oscillations of the boat. A feed and bilge pump assures the circulation of the water.

The gas enters the expander directly and mixes with the air in a special box. The ignition of the explosive mixture is effected by means of an electric spark, as in the ordinary types of the Simplex.

The motor is of an effective 40 horse power. It actuates a two-bladed screw of reversible pitch, and is installed in the stern of the boat.

The Screw.—The screw, which is of the MacGlasson type, is of a reversible pitch that permits of obtaining every speed from the lowest to a maximum without having recourse to varying the velocity of the motor. Such speeds are obtained as easily in a backward as in a forward motion. The internal arrangement of the boss of the screw permits of varying the inclination of the blades, thanks to a system of very simple lever arm. This screw is controlled either from the engine room or from the deck by means of a simple handle. The pilot has under his control both the steering of the vessel and its propulsion, and is able to vary them instantaneously and according to any velocity, backward or forward, without any aid from the engineer. The latter finds his role limited to a simple surveillance. How many accidents there are that have happened at sea and upon rivers from the fact that the captain or the pilot has not had the motive power under his hand at the precise moment in which a modification in the running had become urgent! The suppression of boilers carries with it that of many chances of accidents, either from explosions or fire, and reduces the personnel of the engine to one man.

Trials.—The following are the principal results obtained in some of the trials that have been made. On Saturday, June 2, 1894, the motor was set in operation in situ for an hour with a gas pressure of 40 atmospheres in the tubes. This pressure fell to 12 atmospheres.

There were but eight tubes employed, and these contained gas that had been compressed for four days. No heating was observed in the motor. On Sunday, June 3, 1894, the motor was run from nine to eleven o'clock in the morning and from three o'clock to half past four in the afternoon. The pressure in the tubes was 18 atmospheres. In the evening there remained a pressure of 7 atmospheres in the tubes. Eighteen tubes were employed, and there were no accidents.

On Monday, June 4, 1894, the tubes were filled at the works of the Bellot basin at a pressure of 40 kilogrammes; on board, a pressure of 28 kilogrammes by transfusion. The motor was set in operation at a quarter past three, and kept running for one hour and twenty minutes, and again at five o'clock with a run of fifteen minutes. The pressure remaining in the tubes was 12 atmospheres. Movement of variation of the screw—forward, backward, stoppage—perfect. The change of direction was rapid. There was no leakage in the joints of the tubes. The screw made from 170 to 260 revolutions per minute according to the introduction of the gas, and the starting was effected in one minute. Fifteen starts were made after a complete stoppage without any trouble and always in one minute.

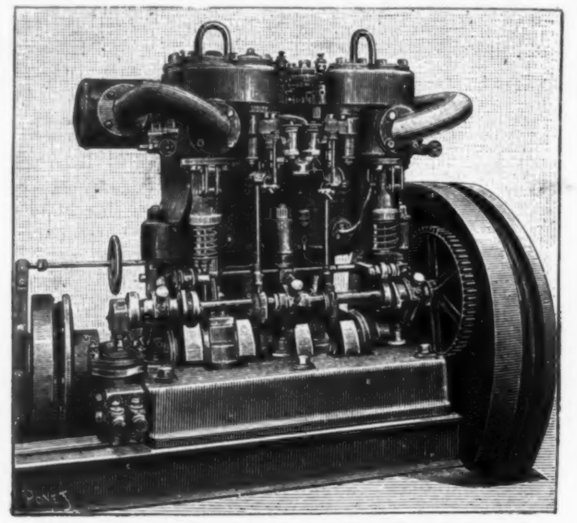


Fig. 2.—COMPRESSED GAS MOTOR.

On Sunday, June 10, 1894, some new trials in the course of a trip were made upon the Tancarville Canal, starting from Havre. Despite the five or six bridges of the canal, the boat ran at the rate of 10 kilometers an hour—exactly 1 kilometer in six minutes. There were 80 tons of ballast on board, representing an equal quantity of freight. The wind was ahead. The cranks that actuated the screw shaft, which revolved at the rate of 200 revolutions per minute, remained cold. The expander worked well. The speed of the boat might have been increased had the way been clear.

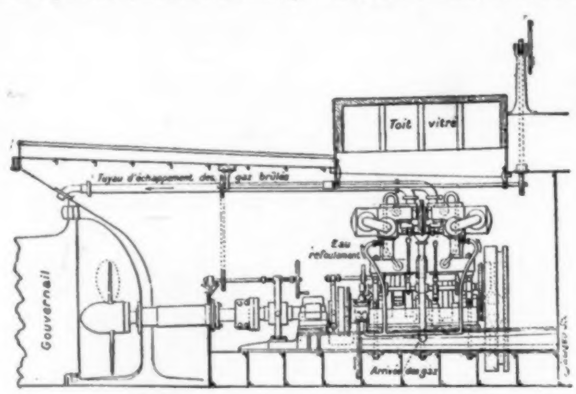


Fig. 3.—MARINE ENGINE OF THE BARGE IDEA, WITH SCREW OF REVERSIBLE PITCH.

A few weeks after this, a trip was made to Tancarville. The voyage, going and returning, was 72 kilometers. The ballast had been increased to 145 tons. The mean speed obtained was 11·5 kilogrammes an hour. Later still, in a trip to Trouville, in quite rough water, a distance of 13 kilometers was made in one hour and ten minutes.

These first results are satisfactory and render the outlook favorable for future successes.

The applications to which these studies will give rise may be very numerous, and may possibly be adapted equally well to river or canal transportation service, as in this particular case, to the multiple services of ports of war or commerce, to pleasure craft on the large lakes, or, finally, to fishing smacks, whose management, etc., it will considerably simplify.

The gas, according to the locality and the service to be realized, may be of very variable composition, and be used in the form of city, poor or naphtha gas. The form and dimensions of the motors will vary according to the richness of the gas and the results to be obtained, but the first are already constructed and we can clearly judge as to what we can expect from them. Modifications and improvements will very naturally follow, and in a few years we shall be able to see numerous public services operating by this system, unless the reduction of the duty upon petroleum shall make this liquid fuel a formidable competitor of compressed gas.—La Nature.

Fig. 1.- THE IDEA, A BARGE PROPELLED BY A COMPRESSED GAS MOTOR.

MULTIPLE DRILLING MACHINE FOR WHEELS.

We illustrate, Fig. 1, a multiple drilling machine, made by Messrs. George Richards & Company, Limited, of Broadheath, near Manchester, for the Horwich

Fig. 2.

works of the Lancashire & Yorkshire Railway Company, and intended for drilling through the steel rings, wood cushion, and steel web of railway carriage wheels, as indicated in Fig. 2, automatically and at one setting. The table of the machine rests on a trolley, as shown in the illustration, this latter being mounted on rails for carrying the table and wheel to the front and back of the machine as desired. The

wheel is centered by means of a mandrel fixed in the table, which passes over the two slides on the standards, and is brought into position by means of taper steel pins fitting into hardened bushes; the feed gear is then put into motion, and operates automatically throughout, returning the table with the wheel to its original position. The machine carries 12 spindles, equally divided so as to become interchangeable, each spindle receiving its motion from a large spurwheel running on a fixed spindle in the center of the frame. Attached to this is a large bevel wheel, geared 3½ to 1 to the driving shaft carrying fast and loose pulleys. The spindles are provided with gun metal bushes at the top end, and conical taper bearings at the bottom, in addition to a split conical chuck suitable for parallel

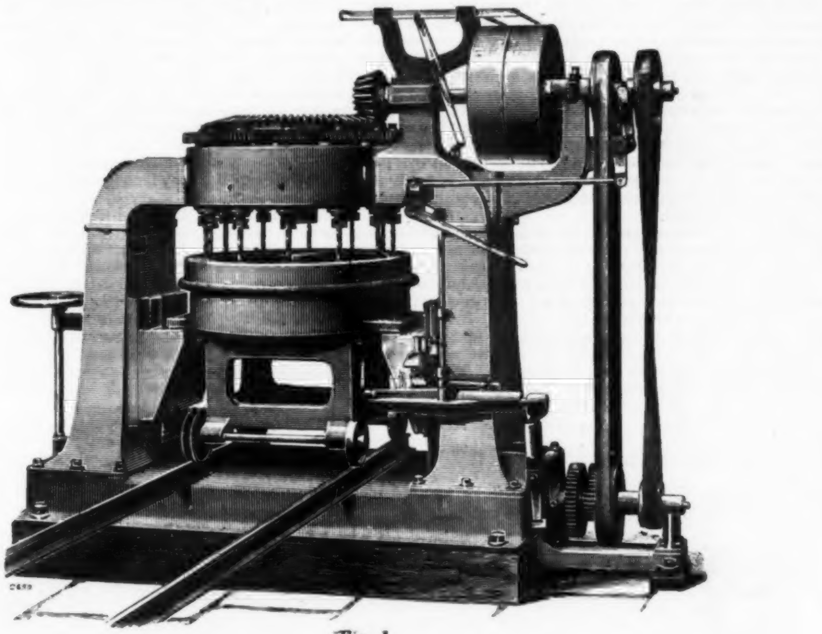


Fig. 1.

MULTIPLE DRILLING MACHINE.

drills, so that drills of varying lengths can be set on one level. The feed motion is driven by a secondary shaft, running the whole length of the bottom framing of the machine. This shaft is actuated by open and cross belts from the top shaft, and is provided with a clutch and bevel wheels, by means of which it drives the vertical shaft for raising and lowering the table by hand. The gearing on the feed shaft is arranged for giving feeds for the steel of 200 turns to the inch, and for the wood of 20 turns to the inch, with a fast return for carrying the car wheel down into its original position. The feed is governed automatically by inclined planes and adjustable stops, and can be reversed by a hand lever in front of the machine, fixed stops being provided on the vertical rod attached to the hand lever to prevent the overrunning of the feed in either direction, by throwing the clutch in connection with the feed pulleys at the top into its central position.—Engineering.

A PORTABLE ROWBOAT.

WE represent herewith a type of rowboat that will permit lovers of boating to change their centers of excursion as easily as cyclists do theirs. It consists of three parts connected with each other by means of thumb screws. The tightness is assured by a coat of tallow. The central portion, in which the two oarsmen and the steersman sit, is but 9 feet in length. The other parts are about one-half less in length. The whole is therefore transportable, like baggage, in express trains. A T-cart that can be taken apart permits of converting the boat into a hand cart for carriage upon the highway, as shown in Fig. 1. This cart, which does not exceed much more than 200 pounds in weight, can be pushed by one man without any fatigue.

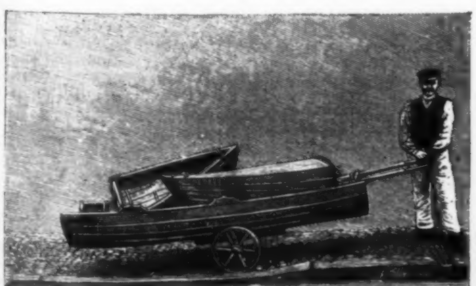


FIG. 1.—PORTABLE ROWBOAT IN SEPARATE PIECES.

FIG. 2.—PORTABLE ROWBOAT MOUNTED.

These various combinations therefore permit of reaching the watercourses that it is desired to explore, with the greatest facility. The railway charges are insignificant when there are three in the party.

The boat, when mounted, is 18 feet in length and about three feet in width at the upper part, Fig. 2. Its bottom is nearly flat, and, thanks to its extreme length and its width, it resists strong eddies and waves very well. It sinks but 8 inches in the water with three persons, and is therefore capable of navigating in the smallest watercourses. Its manageability permits of easily crossing roadways. The mean speed obtained without effort by two rowers is four miles an hour in calm water.

The boat experimented with has traveled 900 miles under the most varied conditions. It cost fifty dollars, half the price of a good bicycle, and despite the severe ordeals that it has undergone in certain torrents, no serious damage has yet happened to it.—La Nature.

TIMBER PRESERVING METHODS AND APPLIANCES.*

By W. G. CURTIS.

PREFACE.—This paper is not intended as a general review of wood preserving appliances, but is written to describe a portable wood preserving plant recently put into successful use on the Pacific system lines of the Southern Pacific Company, with a concise statement of the methods of using this plant for burnettizing ties. Also to present to the society some brief notes on the modifications of the ordinary methods of creosoting timber as practiced at the fixed creosoting plant in Oakland; these modifications having been found necessary to successfully creosote Pacific coast timber, and resulting in more satisfactory treatment of the timber, coupled with a decrease in the expense thereof, as compared with ordinary methods.

While the chief source of supply for railroad ties on the Pacific coast is drawn from the California redwood timber region, the redwood timber being very durable with respect to decay, but also being a soft timber requiring tie plates for the best results, where traffic is considerable; a large portion of the tie supply for Nevada, Utah, Northern California and Oregon can be most economically drawn from the pine and fir forests of Oregon and the Sierra Nevada range in California. The supply points for this timber, however, are widely separated, the distance between the most easterly and the most northerly supply being 789 miles. Intervening between these two points are high mountain ranges, the rise and fall of grades, westerly and northerly, being respectively 1,080 and 15,500 feet.

The Southern Pacific Company's experience, on their Atlantic system lines, as well as the results of some experiments made in California, demonstrates the economy of treating the pine and fir ties with zinc chloride.

One wood preserving plant, having a capacity for treating about 2,500 ties per 24 hours, is amply large to burnettize all of the ties required for the Southern Pacific lines naturally supplied with ties from the pine and fir forests. The conditions are such, however, that to locate the plant at some station in the ordinary way would involve a very great cost for hauling the ties from delivery points to the wood preserving works and thence to point of use. The cost of four fixed plants, which would be required to reduce the cost of transportation to reasonable limits, was also out of the question. These difficulties led to the design of a portable plant, which was put into operation in June, 1894. The photograph before you shows the plant as assembled for the treatment of ties by the burnettizing process at Chestnut Station, California.

The plant comprises all of the appliances essential for creosoting, burnettizing, and all of the ordinary wood preserving processes; one car carrying two steam boilers, steam winch, tools, wire rope, etc.; one car carrying superheater, measuring tank, force pump, air and circulating pump and condenser; two cars, each carrying three wooden supply tanks for holding the preservative fluid, each tank having a capacity of 4,000 gallons, or a total capacity of 24,000 gallons, and two retorts, each 6 ft. diameter by 114 ft. long, divided into two sections, each section carried on two heavy car trucks. This plant, made up into a train of eight cars, made its initial journey from Sacramento, Cal., to Cornelius, Ore., 706 miles, last May, passing over 3·3 per cent. grades and around the 14° curves of the Siskiyou Mountains without difficulty.

Arrangement of Tracks.—There are two arrangements of tracks used with this plant; first, when the bulk of the ties treated are for local distribution and, second, when the ties are, in the main, to be shipped to more or less distant points. In the first case, a through track is laid alongside of each retort; the tank and machinery cars are then placed on tracks beyond or outside of these tracks, ties are received on flat cars, loaded thence on the retort trucks for treatment, passed through the retorts, and, on emergence at the further end of the retorts, are in position to unload on the same cars on which they were received; these flat cars having in the meantime been moved along the through tracks past the retorts to their new position for receiving loads. In this plan of working it is necessary to provide one empty flat car with every four loaded cars when received at the works, as the increased weight of ties by treatment necessitates the loading of fewer per car.

In the second case it is not necessary to run the tracks through the works, as the ties are, in the main, received on flat cars and loaded for distribution in box cars, so that both loaded and unloaded cars are switched in on their respective tracks and afterward pulled out in the direction from which the cars come.

In both cases a slight grade is given to the loading and unloading tracks in such direction as is most convenient for moving the cars by hand without necessitating the continuous use of a locomotive at the works.

Setting Up.—The ground tracks and foundations (made of tie blocking), having been prepared for the reception of the plant, the retorts are run into position, lined up and adjusted to height by jackscrews, which form part of the tracks supporting the retorts; the trucks are then blocked up with steel wedges so as to take the weight off the springs, and the trucks at the center joint are blocked lengthwise. The end trucks are free to move endwise, so as to act as expansion rollers. The middle connection between the halves of each retort is then made, the tank and machinery cars are run into position and pipe connections made. All large pipe connections between machinery cars, tank cars and the retorts are made with ball and expansion joints; the latter allow a play of some four feet, so that inequalities of track, both in height and distance, are provided for. The smokestack is raised with a gin pole and guyed; the winch is placed in and below one of the end platforms and between the treating tracks, so that the engineer can see the charge as he works the winch. The wire cable for handling the charges is run under the platforms, from the winch to a snatch block at each end of the platforms, thence it returns on top of each platform.

Process of Charging and Handling Ties.—The ties received at the works are placed on tracks adjoining the retort platforms and are thence transferred directly to the retort trucks, being laid thereon in bunches cylindrical in form, bound together and to the trucks by small chains, "sticking" pieces of iron one-quarter to three-eighths of an inch thick being placed between each layer of ties. Two ropes called "pennants" are strung under the charge. These are wire ropes having an eye in each end and are a little longer than a charge of ties. One end of a pennant is fastened to the foremost truck and one end of the other is fastened to the hindmost truck; the back rope from the winch is fastened to the former and the pulling rope to the latter, so that the charge is hauled into the retorts by pulling on the hindmost truck, which pushes those ahead into the retort. The object of this is to dispense with couplings between the trucks, and so economize room in the retorts. As the length of the retort is about the same as that of a charge of ties (14 lengths), it is necessary for the engineer to place the charge quite accurately. The object of the connection with the back rope from the winch is to enable the engineer to reverse and pull the charge slightly back in case it overruns, as occasionally happens, or to stop the load accurately by braking the back line. The charge having been run into the retort, the winch lines are unhooked from the pennants and the ends of the latter thrown under the charge. The doors of the retorts are now closed and screwed up by hand wrenches. On the first screwing up of the retorts not much trouble is taken to get them quite tight, as this can be done better later on when the vacuum is started in the retort.

Method of Burnettizing Treatment for Railroad Ties.—First, the charge is run in and the heads or doors closed and bolted up.

Second, a preliminary vacuum is begun; this is run up to about 20 inches. During this vacuum the doors are bolted up tightly. This vacuum process requires about ten minutes.

Third, live steam is let in at about 30 pounds pressure and continued for about four hours and a half. It is then blown off, requiring half an hour. During this steaming and blowing off the retorts are drained.

Fourth, a second vacuum is created of from 22 to 26 inches, which is maintained for about an hour.

Fifth, the retort is filled with the zinc chloride solution and pressure begun. This is continued until the required quantity of solution is injected into the ties.

Sixth, the surplus preservative fluid is drawn off, the doors opened and the charge pulled out on the platform. Another charge, which has in the meantime been made ready, is immediately pulled into the same retort to undergo the same process. The treated ties are unloaded on to adjoining cars, the trucks pushed

* A paper read by W. G. Curtis, Assistant to the General Manager Southern Pacific Company (Pacific system), before the Technical Society of the Pacific Coast, December 7, 1894.—Railroad Gazette.

BURNETTIZING ON THE SOUTHERN PACIFIC RAILROAD—TABLE OF PROPORTIONAL PARTS.

Gallons standard solution = 1·7 per cent. Zn Cl_2	1·00	2·984	6·94	14·492	13·038	12·979	4·144	4·5	5·25	1·686
Pounds stock solution = 43 per cent. Zn Cl_2	0·335	1·0	2·326	4·856	4·369	4·349	1·389	1·508	1·759	0·565
" pure zinc chloride = Zn Cl_2	0·144	0·43	1·0	2·088	1·879	1·87	0·597	0·648	0·757	0·243
" pure metallic zinc = Zn	0·069	0·206	0·479	1·0	0·9	0·896	0·286	0·311	0·362	0·116
" zinc dross or skimmings = 90 per cent. Zn	0·077	0·229	0·532	1·111	1·0	0·995	0·318	0·345	0·403	0·129
" pure hydrochloric acid gas = HCL	0·077	0·23	0·536	1·118	1·006	1·0	0·32	0·347	0·405	0·13
" commercial muriatic acid = 32 per cent. HCL	0·241	0·719	1·675	3·494	3·144	3·125	1·0	1·086	1·267	0·407
Number of ties 6″ × 8″ × 8′	0·222	0·663	1·542	3·22	2·897	2·884	0·921	1·0	1·165	0·375
" " 7″ × 8″ × 8′	0·19	0·568	1·321	2·759	2·482	2·471	0·789	0·858	1·0	0·321
Cubic feet of timber	0·593	1·768	4·112	8·587	7·735	7·591	2·455	2⅔	3⅛	1·0

Standard solution: 2⅛° Baume, $1\frac{7}{10}$ per cent. zinc chloride, 1·017 specific gravity, 8·472 weight per gallon, 14,000 gallons reserve.

to a small transfer table at the end of the platform, transferred to the opposite track of the same platform and loaded with fresh ties to be run into the other retort for treatment. Trucks sufficient for three charges of ties are used.

In steaming, live steam at a temperature of about 260° F. is used, corresponding to a gage pressure of about 20 pounds. Preservative fluid is injected at a temperature of about 150° F. A maximum pressure of about 140 pounds is allowed in injection; with freshly cut ties, however, 120 pounds is not usually exceeded.

The total time of treatment averages about eight hours and a half, and, as the retorts are run nearly alternately, we get from noon one day to noon the following day five charges treated, or a total of 2,520 ties, 7 in. × 8 in. × 8 ft., per day of 24 hours. If, however, all the ties are new or freshly cut, the time is reduced so as to get out six charges per day, or 3,024 ties in all per day of 24 hours.

We find the time required varies greatly with the kind of timber and with the time during which the ties have been seasoning. California mountain pine, fir and spruce require less time than Oregon fir, and all timbers are more readily treated when freshly cut. An Oregon fir tie, seasoned in the air for two years, will take double the time for the treatment required for one freshly cut. Occasionally a close grained, well seasoned tie will not receive the preservative at all, the fluid penetrating into the sides only about half an inch.

Much attention has been given to this point to provide means of watching the effect of the various steps in the process, so as to vary the treatment as the timber requires it. The retorts are provided with thermometers, the steam pipes with a pyrometer and all tanks with gages; the condenser is provided with a measuring well, all injection is from a gaged measuring tank and sample ties are tested and reported from each batch, as noted further on. The principal blanks used for these and other reports are appended hereto. The condensing apparatus consists of one set of ordinary surface condensers (connected to the vacuum pipe and between the retorts and air pump), which is over and supported upon a measuring well, into which all condensed saps and vapors flow, thus preserving a constant surface for condensation. The measuring well is provided with a glass gage, and is of such dimensions that each foot of the glass gage represents one-fourth of a pound of water extracted per cubic foot of timber. This well is so arranged that it can be emptied without stopping the air pump. By this means any desired dryness of the timber may be accomplished with certainty. In the practical operation for the treatment of ties the extraction of moisture is stopped when the rate, as shown by the condenser gage, is reduced to one pound of water per cubic foot per hour.

Mixing the Fluid for Use.—Concentrated solution of zinc chloride, called "stock solution," as formerly purchased and now manufactured at the works, consists of about 43 per cent. pure zinc chloride, 2 per cent. of impurities (iron, aluminum, lead, etc.) and 55 per cent. of water. This is weighed out and mixed in a small lump, with a proper proportion of water, thence pumped into the wooden supply tanks, tested with a Baume hydrometer, and, if necessary, a slight addition of either stock or water added, so that the liquid for use, called "standard solution," registers 2⅛° Baume at 60° F. The theoretical proportions for the desired standard solution, containing $1\frac{7}{10}$ per cent. pure zinc chloride, are 34·46 pounds stock of 43 per cent. zinc chloride to 100 gallons of pure water; but as there is much evaporation during the process, the tendency of the standard solution is always to get stronger, so that on a continuous run there is added a certain proportion of water to allow for evaporation, or, what is the same thing, to reduce the quantity of zinc chloride to the gallon of water. Experience has taught us that about 27 pounds of zinc chloride stock solution per 100 gallons of water will keep our reserve solution (amount always in the supply tanks) together with that added for daily solution, up to the standard; but this is carefully watched and additions made one way or the other, as the case demands, so that the standard, when injected into the ties, is always $1\frac{7}{10}$ per cent. strong. The standard solution is heated to 156° F. by turning steam through coils in bottom of tanks before being pumped into the charge.

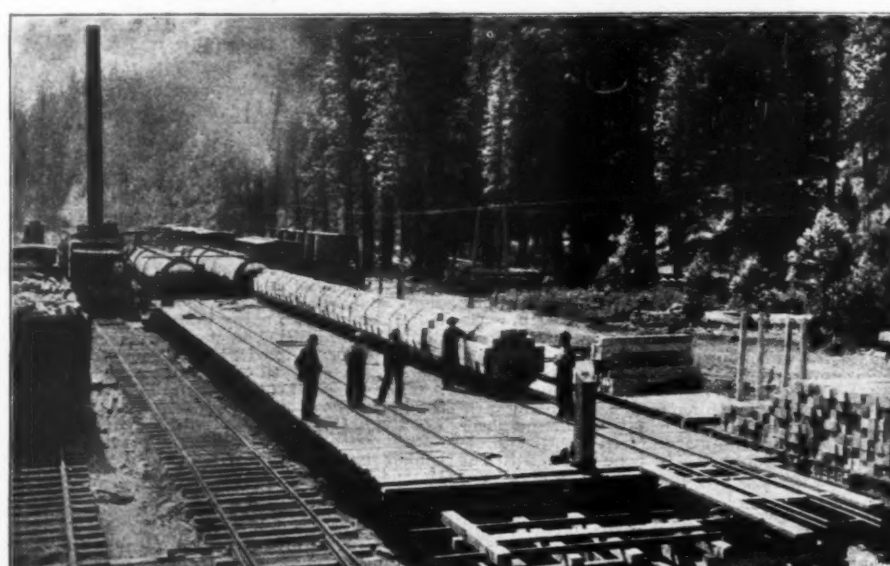
Testing Ties.—At intervals during the regular progress of the work and whenever any charge shows some change in the treatment as to necessary vacuum, time or amount of pressure, and after each change in kind, quality or dryness of timber, four sample ties are taken from a charge consisting of ties of average grain, one heaviest, one lightest, and two average weight, and each tie is bored in the middle of its width and length with a one inch bit. The first half inch of borings is thrown away, after which each inch of borings is preserved separately and designated as one inch, two inch, and three inch specimens. Each specimen is burned to an ash over a gasoline jet in a porcelain roasting dish in contact with the air. The ashes are carefully collected in a platinum cup, distilled water added, with a slight excess of hydrochloric acid, converting the zinc oxide into zinc chloride. It is then filtered into a test tube, and the zinc hydrate thrown down with sodium carbonate, making a white flocculent precipitate. The liquid is then made up with distilled water to three drachms. The resulting milky fluid is compared with standard liquids in tubes of the same size as the test tubes, each tube containing three drachms. The standard liquids are graded to represent 6, 9, 12, 15, 18, 21, and 24 one-hundredths of a pound of zinc chloride per cubic feet of timber. As shown by the annexed table of proportionate parts (for which, as well as for much of the other data in this paper, I am indebted to our fellow member, Mr. J. D. Isaacs, who has designed almost all of the details of the plant, and devised many improvements in the method of operation), the maximum of zinc chloride, for cubic foot of timber desired, is twenty-four one-hundredths of a pound. We are so certain of what we are doing by our methods of observation that the tests are principally of value as checks. Recent tests have sometimes shown a minimum of twenty-one one-hundredths, but usually indicate the full amount. It is to be recollected that this minimum is from the geometric center of the tie. In such cases specimens taken nearer the ends show prescribed quantity. After boring the ties are plugged with creosoted sticks turned to a tight fit, and shipped for use with the rest.

Records.—A tabular record of each charge, giving all dates, times, durations, pressures, and temperatures, is kept and charges numbered; a similar tabular record of all tests is kept and duplicates forwarded to headquarters. All ties are stamped on the ends with the month and year of treatment.

We have found it economical and convenient to manufacture our own chloride of zinc stock solution. The apparatus is simple and inexpensive, and requires little attention. It consists of three lines of barrels arranged in steps. Beginning at the top and numbering them 1, 2, 3, 4, 5, and 6, they are arranged as follows:

No. 1, bottom 3 in. above top of No. 2, and has a lead spout emptying from the bottom into the top of No. 2.

No. 2, bottom 12 in. above bottom of No. 3, and has a lead pipe from near bottom to top of No. 3.



SOUTHERN PACIFIC WOOD PRESERVING PLANT.

No. 3, bottom 6 in. above bottom of No. 4, and has a lead spout from near bottom to top of No. 4.

Nos. 4 and 5 same as No. 3, each emptying in same way into that below. Each barrel is charged with about 600 lb. of zinc.

The carboys of muriatic acid are lifted to a platform beside barrel No. 1, through which the acid trickles rapidly, taking off, so to speak, its wire edge; that is, preventing violent action in barrel No. 2. In barrel No. 2 some ebullition takes place. The heavier, partially formed chloride sinks to the bottom, passes up through the lead pipe, and over into No. 3, and so on. We found it necessary to raise barrel No. 2 higher than the rest of the series in order to get head for flow through its discharge pipe, some of the head being lost by the upward action of the hydrogen gas and steam. A continuous stream of zinc chloride, completely saturated as to the acid, runs from the pipe of No. 5, but to make certain, we run through No. 6; thence into storage barrels standing ready for use. The capacity of the chemical plant is about 5,000 lb. of stock solution per ten hours. After each carboy of acid is emptied, one-eighth of its weight in water is thrown into barrel No. 1, which has the effect of cooling the zinc, keeping down somewhat the ebullition in barrel No. 2, and supplying water evaporated. The loss of chlorine by evaporation is about one per cent. We find a better result by this process than by allowing the acid to simply stand on the zinc. The resulting zinc chloride stock solution has a density of 50° Baume and contains 43 per cent. of zinc chloride.

Creosoting or Impregnation of Timber with Dead Oil of Coal Tar.—The portable plant is arranged for creosoting timber also. This requires only the additional adjuncts of a superheater and steam coils in the retorts. Although we treat sawn timber with creosote, the bulk of the timber treated is in the form of round piles of Oregon fir. The material proved to be extremely difficult of treatment by any of the standard methods. The temperatures and pressures had to be forced and the time required was very long (32 to 38 hours) to get any effective penetration. The piles after treatment were badly split and checked and their strength seriously impaired.

In November, 1891, some experiments were undertaken with a view to overcoming these objectionable results. These experiments lead up to our present standard creosoting process, which closely corresponds with the methods advocated by Boulton ten years or more ago. We merely boil the timber in the dead oil, and when sufficiently dry inject the oil by pressure. In effect we have returned to the open vat process tried fifty years ago, plus pressure in a closed retort. An open vat for boiling, followed by the introduction of the timber into a closed receptacle for injection, would answer the same purpose, but we find it more convenient to perform both parts of the process in the same retorts. In this process we use no vacuum, but pass the vapors, during boiling, through the surface condenser, leaving the outlet from the latter open to the air. The object in using a condenser is to enable us to measure the sap extracted from the timber and to recover the lighter portions of the creosote carried over with the vapors of sap. Every foot in the measuring well of the condenser corresponds to ½ lb. of water, or sap, per cubic foot of piles treated for average loads, and we find that the piles are practically dry when the condenser gage shows 6 in. per hour. The same precautions as in burnettizing are used to follow the characteristics of each load and to vary the treatment accordingly.

The result of these changes in treatment has been most satisfactory. The time has been cut down to 12 to 14 hours per charge, as against our former time of 32 to 38 hours, and as against that required in present Eastern practice of 22 to 27 hours. Temperatures are reduced from 280° F. to 240°; pressure reduced from 200 lb. to 120 lb.; fuel about one-half formerly used per charge. The timber is practically uninjured by the treatment. It is less checked than in ordinary air-seasoned timber, and whatever checking takes place is during the boiling, so that all checks are well filled with creosote.

In common with timber in burnettizing, the greener the wood is the more easily it is impregnated with creosote. No difficulty is experienced in securing any desired penetration.

Memorandum of Experience with Treated and Untreated Ties.—The treatment of ties with preservative substances was commenced in Europe as early as 1838, perhaps earlier. Of the many and various materials treated with on a large scale, only about four seem to have been used to any considerable extent. These were sulphide of copper, bichloride of mercury, chloride of zinc, and creosote oil, and of these four only two seem to have survived for general use, namely chloride of zinc and creosote. The former, on account of its comparative cheapness, is the one most commonly used.

The average results of tie preservation in Germany, where perhaps more careful records have been kept and investigations made than elsewhere, indicate that the life of railroad ties (so far as decay is concerned) is almost exactly doubled by preserving them.

In November, 1889, a small number of burnettized ties were put in the track, in a gravelly clay roadbed, near Tucson, Ariz., and an inspection just made, after four years and eleven months of service, shows that all of these burnettized ties are perfectly sound. At the same time and place various untreated ties were put in the track adjoining the burnettized ties; of these Truckee white fir has decayed to a depth of about ¼ of an inch on the under side; Truckee yellow pine has decayed to a depth of from 1 to 3 in. on the under side; Truckee red fir ½ in. decayed on under side; Truckee tamarack and Truckee sugar pine decayed from 1½ to 3 in. on the under side; Shasta white fir and white yellow pine decayed on under side from 1 to 4 in.; Shasta red fir decayed on under side to a depth of from 1 to 2 in.; Shasta sugar pine decayed on the under side to a depth of from 1½ to 2½ in. The redwood ties, laid without tie plates, under 50 lb. rail, are perfectly sound, but the rail has cut down into them from 1 to 2 in., indicating that the maximum life for such ties in such localities is between five and six years.

In December, 1889, some burnettized ties were laid in the San Joaquin valley, near Turlock station, in a roadbed composed of sandy loam, under 60 lb. rail. An inspection made March 1, 1894, after three and four months of service, shows a slight decay on the under side. Of the ties of similar timber, but untreated, put in the track at the same time the burnettized ties

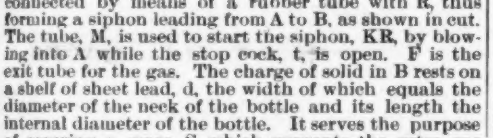
were laid, and adjoining them, the white and red fir were completely decayed and removed from the track in August, 1893, after three years and nine months of service. Of the yellow pine untreated ties, 90 per cent. were removed from the track after three years and nine months of service. Of the sugar pine, untreated, 90 per cent. were rotted down to the danger point and removed from the track after three years and four months of service. The tamarack, red and white fir, yellow pine and sugar pine, from the eastern slopes of the Sierras, near Truckee, untreated, are more or less badly decayed, after three years and four months of service, the indications being that the maximum life of the best of them will fall somewhere between four and five years. Of the 6 in. × 8 in. × 8 ft. redwood ties put in at the same time with very small tie plates, all are sound after five years of service; the plates, which were entirely too small, have bent up considerably, but have not cut down into the ties more than three-sixteenths of an inch. The 6 in. × 8 in. × 8 ft. redwood ties that were laid without tie plates at the same time are cut down under the rail to a depth of 2 in., leaving only 4 in. of sound wood under the rail, and were removed from the track after about three years and nine months of service.

The service life of ordinary redwood ties (which in ordinary roadbeds will last many years without failure by decay) is measured, not by time, but by the volume of tonnage passing over the rails; the speed as well as the weight being a factor in the wear in some proportion not well ascertained. Under average conditions of traffic, redwood ties, 8 in. wide and 6 in. thick, laid about 3,000 to the mile of track, and supporting 60 lb. steel rail, will endure about 13,000,000 tons of cars and engines passing over the track; this amount of traffic being equal to nearly 30,000 trains, each consisting of a locomotive and tender weighing 60 tons and 15 cars weighing between 375 and 400 tons, or say, an average of about 16 trains with a locomotive and 15 cars each per day for five years. The average endurance of 7 in. × 8 in. redwood ties is probably somewhere between 17,000,000 and 18,000,000 tons of traffic. Redwood ties are usually condemned as unserviceable when crushed down so as not to leave more than 4 in. of sound wood under the rail.

SELF-REGULATING GAS GENERATOR.

By W. W. ANDREWS.

THIS form of generator is so cheap and easily set up that it makes it possible for every teacher and experimenter in chemistry to have, at practically no expense, a set of generators capable of yielding, whenever called upon, a supply of hydrogen, hydrogen sulphide, chlorine, carbon dioxide, sulphur dioxide, etc. It consists of an ordinary bottle, A, to serve as reservoir for the acid, a smaller bottle, B, which is the generator proper, and C, the familiar wash bottle. A is closed by a cork holding two pieces of glass tubing. The one, M, just pierces the cork and the other, K, reaches down a short distance below the surface of the acid and is connected by means of a rubber tube with R, thus forming a siphon leading from A to B, as shown in cut. The tube, M, is used to start the siphon, KR, by blowing into A while the stop cock, t, is open. F is the exit tube for the gas. The charge of solid in B rests on a shelf of sheet lead, d, the width of which equals the diameter of the neck of the bottle and its length the internal diameter of the bottle. It serves the purpose of securing a space, S, which prevents the extra gas generated when t is closed from pressing the acid out of the siphon. Instead of a bottle for holding the charge, a calcium chloride tube or an Argand lamp chimney with its larger end closed with a cork or sunk into a wooden block and cemented with paraffine wax, or even a piece of large sized tubing may be used. If the last be used, the space, S, is secured by cutting the lead in the shape, d', and bending it to form a bench to support the solid charge, as shown. d'' is the shape of the lead support to be used in the calcium chloride



tube or Argand chimney. X and X' are the wire springs for holding B to its support, from which it may be lifted or replaced instantly. One is to inclasp the body and the other the neck of the bottle or one of the glass tubes below the cork.

The advantages of this form of generator are:

1. Its cheapness. An ordinary fruit juice bottle and two wide mouthed eight ounce bottles will, with the necessary tubing, make one of good capacity.

2. Its convenience and safety. It is strictly self regulating. If a rubber tube fitted with a glass plug one-half inch long instead of a stop cock be used, the gas flows only when the fingers pinch up the rubber along one side of the plug and ceases the moment they are lifted. The apparatus, therefore, is self-closing. It is very easy to recharge either with acid or solid.

3. It insures a more even quality of gas than the well known Kipp, and as complete utilization of the acid as the Koninck generator. When the gas presses the acid back from B, it enters A laden with dissolved solid and on account of its greater specific gravity it falls in a straight line to the bottom, where it spreads out in a dense layer. When the apparatus is again set working, the purest acid is drawn from the upper layers. There is, consequently, some advantage in using a tall bottle for A.

4. It may be put together in a form with all the advantages possessed by the Schanche generator (see this Journal, December, 1894). Making the glass tube, R, long enough to reach to the top of B, and to curve a little downward, so that the acid may drop on the top of the solid charge and trickle through it. A drainage tube with stop cock must be inserted into the cork to carry off the used-up acid from the space, S. The inverted bottle for B possesses this advantage over the calcium chloride tube or chimney, viz., that owing to the position of the mouth of the gas exit tube, F, solid particles are not so likely to be shot into it when the acid is vigorously attacking the solid charge.

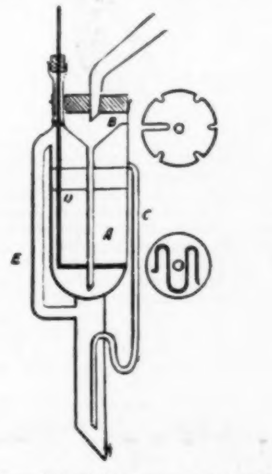
5. The pressure can be regulated at will by placing A at different heights, and this pressure may at any moment be re-enforced by blowing into A, and the re-enforcement held by closing M by means of a rubber tube and pinch cock.

Mt. Allison University, Sackville, N. B.

—Jour. Amer. Chem. Society.

EXTRACTION APPARATUS FOR LIQUIDS.

THE apparatus shown in the figure resembles an ordinary Soxhlet's extractor for solids, save that the



tube, C, is connected with the upper instead of the lower end of the extraction chamber, A, and thus no longer functions as a siphon, but as a simple delivery tube back into the flask containing the solvent. The vapor of the solvent ascending through the tube, E, passes through slots in the sides of the funnel, B, to the condenser, and the resulting liquid flows down the stem of the funnel to the bottom of the liquid to be extracted, through which it rises and trickles over through C to the flask below. D is a glass rod that can be used as a stirrer without opening the apparatus.—A. Kurbatow, Chem. Zeit.

NEW METRIC STANDARDS.

THE president of the Royal Society, with Sir John Evans and the following members of the council, Dr. A. A. Common, Mr. W. Crookes, Dr. A. R. Forsyth, Prof. H. Lamb, Prof. J. H. Poynting, recently visited the Standards Department of the Board of Trade for the purpose of inspecting the new metric standards which have been recently deposited with the department. The president and council were received by Sir Courtenay Boyle, K.C.B., the secretary of the Board of Trade, and Mr. H. J. Chaney, superintendent.

Two new metric standards, of length and mass respectively (des prototypes nationaux), were delivered to the Board of Trade by the International Committee of Weights and Measures at Paris on September 28, 1889, and the third and final standard was received from the committee in December last. All three standards are deposited at the Standards Office, 7 Old Palace Yard, Westminster, and are available for use in the verification of metric standards for the purposes of science.

The two standards received in 1889 include a "line" standard metre measure (mètre-à-traits) and a kilogramme weight. The standard received last year is an "end" standard metre (mètre-à-bouts). These three standards, together with other similar standards supplied to twenty-one different states, are, inter alia, the outcome of the results of the labors of the International Committee for more than twenty years; and Great Britain is the first country which has received all three of such standards.

The standards were verified at the Bureau International des Poids et Mesure (Pavillon de Breteuil, Sèvres, près Paris), which bureau was established under a metric convention, dated May 20, 1875, signed by twenty different high contracting states, exclusive of Great Britain, who finally joined the convention in September, 1884. The committee is a self-elected body, and is founded and maintained by common contribution from all countries who are parties to the convention of 1875. The bureau of the committee is required to be near Paris, and has been declared to be internationally neuter. The committee was charged in 1875 with the construction, restoration, and verification of new metric standards (des prototypes internationaux) to replace the ancient standards of France (mètre et kilogramme des archives), and with the verification of copies of the new standards for all the contracting states. By such means the international accuracy of metric standards is now assured throughout the world.

The committee, which includes thirteen members, undertakes also the verification of standards for scientific authorities or persons.

THE METRE.

The two metric standards above referred to are made of iridio-platinum, or an alloy of 90 per cent. of platinum and 10 per cent. of iridium. The metres are in transverse sections, nearly of the form of the letter X, known as the Tresca form, and selected as being not merely as the most economical (iridio-platinum being a costly metal), but as being less affected by heat, practically non-oxidizable, and well adapted for receiving finely engraved lines. This alloy appears to be of all substances the least likely to be affected by time or circumstance, and has been preferred for standards purposes to rock crystal, gold, etc. The lines on the mètre-à-traits are fine, and are barely visible to the naked eye.

The actual relation of our prototype metre No. 16 is as follows:

At 0° C.

$$\text{No. } 16 = 1 \text{ metre} - 0{\cdot}6\,\mu \pm 0{\cdot}1\,\mu \text{ at } 0^\circ \text{ C.}$$

Here μ means one micron, or one-thousandth of a millimetre (or nearly 0·00004 inch), so that metre 16 may be said to have been verified with an accuracy of one part in a million.

The certificate of the verification of the end standard, or mètre-à-bout (étalon No. 6), will not be issued by the committee until their general conference in September next; but this standard has been verified also with great accuracy, with a probable error of ± 0·3 μ. In the verification of the end standard (mètre-à bout) MM. Cornu and Benoit have introduced a method of reflection, by means of which it is unnecessary to bring the ends of the metre bar into contact with any touching surfaces, and thus the measuring ends of the bar may be carefully preserved and used. Only Austro-Hungary, Germany, Great Britain, and Russia have at present applied to the International Committee to be supplied with end standard metres.

Experiments with reference to light wave analysis, which have been carried out under the directions of the International Committee by Dr. Michelson during 1893, with the view to the discovery of a radiation of light of sufficient homogeneity to serve as an ultimate standard of length, appear to show that it is possible within certain limits to reproduce the length of the metre by reference to such physical constant.

THE KILOGRAMME.

The unit of mass of the kilogramme is determined by a piece of iridio-platinum in the form of a cylinder, the height and diameter of which are equal (thirty-nine millimetres). The kilogramme, No. 18, supplied to Great Britain has no distinguishing marks, and is highly polished. On analysis it showed very faint traces of ruthenium, rhodium, and iron. Its volume was found to be at 0° C.

$$\text{Prototype } 18 = 46{\cdot}414 \text{ millilitres,}$$

corresponding to a density of

$$21{\cdot}5454.$$

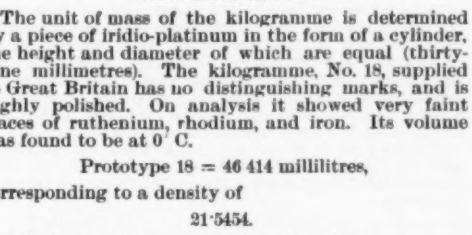
After its final adjustment it was found to be in vacuo at 0° C.

$$\text{Prototype } 18 = 1 \text{ kg.} + 0{\cdot}070 \pm 0{\cdot}002 \text{ milligramme.}$$

So that it may be said that the kilogramme (kg.) has been verified with a probable accuracy of 0·002 parts in a million.—Nature.

VACUUM EVAPORATING APPARATUS.

THE evaporation of large volumes of liquids in the chemical laboratory is a tedious and lengthy operation; if a free flame is employed, there is a danger of loss of material, and there is no alternative but to use the water bath. But many solutions—for example, sugar solutions—cannot be heated at the temperature of the water bath without decomposition, besides which they cannot be concentrated to a sirupy condition as quickly as is desirable. The most rapid mode of procedure, in which decomposition is prevented, is evaporation under diminished pressure. By the aid



LABORATORY VACUUM EVAPORATING APPARATUS.

of the apparatus figured here, 4 liters of water per hour may be evaporated at a temperature of 32 deg. to 35 deg. C.; or, if the condenser be surrounded by a freezing mixture, the same quantity of water per hour may be evaporated at 24 deg. to 26 deg. C.

The glass flask, A, which serves as a vacuum pan, rests on a copper water bath, B, having a rim adapted to it. The pear-shaped piece, C, is in connection with an arrangement for charging the flask. The caoutchouc tube, E, surrounded by wire spiral, serves to connect the flask with two large globular condensers of the author's well-known construction. The

tube, G, furnished with a tap, leads to a graduated Wulff's bottle, which receives the distillate. To the second tubulus of the Wulff's bottle is attached a T piece, one limb of which is in connection with a Korting's water pump and the other with a mercury manometer.—Soxhlet, Chem. Zeit.

[FROM THE ASTROPHYSICAL JOURNAL.]

NOTES ON SILVERING SOLUTIONS AND SILVERING.*

SINCE the first introduction, a half century ago, of Liebig's method of silvering glass by deposition from the solution of a silver salt, a number of modifications of the process (consisting usually in some variation in the reducing agent employed to precipitate the silver) have been proposed, some designed to cheapen the cost of the method by securing a larger percentage of deposited silver and others to render the deposited film harder and more enduring. Of this latter class that which was originated by Brashear is one of the most successful, as it gives a film so hard and adherent that it may be rubbed vigorously with the hand or with a pad of cotton, while it is still wet from the silvering bath, without injury. A description of the process was published some years ago by Mr. Brashear† and is now very generally used by professional makers both in the United States and in England, but it is not as generally well known among scientific men as its merits deserve. It was described to me about a year ago by Mr. Brashear himself, and since that time it has been used exclusively in silvering the large mirrors (one of which is 36 cm. in diameter) used on the siderostat and spectro-bolometer of the Smithsonian Astrophysical Observatory. It has given excellent results, and for the benefit of those who are unacquainted with it I will describe it briefly, giving the proportions both in grammes and cubic centimeters and in the English units used by Mr. Brashear.

The composition of the reducing solution is as follows:

Loaf sugar or rock candy	90 grms.	or 840 grains
Strong nitric acid (sp. gr. = 1·22)	4 c. c.	or 40 grains
Alcohol	175 c. c.	or 3½ ounces
Distilled water	1000 c. c.	or 25 ounces

This is made up by dissolving the sugar in the distilled water and then adding the alcohol and the nitric acid. It should be prepared at least a week before it is used, and, unlike most solutions for this purpose, the longer it stands, the better it gets. A quantity sufficient to last a year or more may therefore be made up at one time.

The silver solution is an ammoniacal solution of the oxide, precipitated as in the ordinary process from the nitrate, to which just before using is added a solution of caustic potash in the proportion of ½ gramme of potash (KOH purified by alcohol) to 1 gramme of the silver salt. If very much silvering is to be done, both the ammoniacal solution of silver and the caustic potash solution may be kept in stock and mixed as required, but better results will be obtained if this part of the silvering bath is made up as it is wanted.

The amount of silver nitrate, potash and ammonia, and the corresponding quantity of the reducing solution required for different sizes of mirrors will be about as follows:

For Mirrors.	Area.	Silver Nitrate ($AgNO_3$).	Caustic Potash (KOH).	Ammonia* $NH_4OH + H_2O$.	Reducing Solution.
30 cm. diam.	707 sq. cm.	15 grms.	7·5 grms.	12 c. c.	85 c.c.
25 " "	491	11	5·5	9	65
20 " "	314	7	3·5	6	40
15 " "	177	4	2·0	3	25
10 " "	78.5	1.8	0·9	1½	10
5 " "	19·6	0·5	0·25	½	3

* The amount of ammonia will of course vary with the strength of the solution. The quantity here indicated is for ammonia of sp. gr. about 0·88.

In English units these quantities correspond to 120 grains of nitrate of silver and 60 grains of potash for a mirrior 8½ inches in diameter.

The bath is made up as follows: The silver nitrate and the potash are dissolved separately, each in about 100 c. c. of water per gramme of salt. To the silver solution is added about one-half the ammonia, and the remainder is diluted with distilled water in the proportion of 1 to 5, and then added more slowly until the silver precipitate is barely redissolved. During the last part of the process the solution should be constantly agitated, and the vessel which holds it should be occasionally lifted or shaken so as to wash down the sides. (A Florence flask is much to be preferred to a beaker for this operation, because of the greater facility with which it may be handled.) The potash solution is now added and mixed thoroughly, and if a precipitate remains, dilute ammonia is added until it is not quite redissolved, using the same precautions as before. At the end the liquid should have a slight brownish color, indicating the presence of a little free silver oxide. It should be allowed to stand for a few minutes, and then, if there are many floating particles, it is filtered through coarse filter paper or cotton, after which it is ready for use.

A slightly different mode of procedure is recommended by Mr. Brashear. About 1/10 of the original silver solution is reserved, and, after the balance has been treated as already described, the reserve silver is added slowly until another distinct precipitate is formed; then a little more ammonia until it is redissolved, then a few more drops of silver, and so on until all the reserve silver has been added, taking care to make the last addition silver solution and not ammonia.

If care is taken to use as dilute a solution of ammonia as recommended above, and to agitate the solution thoroughly during its addition, the first method will be found perfectly satisfactory. It is, however, well for beginners to adopt the latter plan until they learn to recognize from the appearance of the solution the presence of free silver oxide.

"It is useless to attempt to silver without having a slight excess of silver in the solution."

The solution having been filtered as above described (if there are no floating particles, this filtering will be unnecessary), the required amount of reducing solution is added, the whole thoroughly mixed and poured into the dish in which the silvering is to be done, and the mirror, which has previously been cleaned (of which more hereafter), immediately immersed face up or down, as the operator prefers. I myself always prefer to silver face up, as the progress of the deposit may then be watched and arrested when it has proceeded far enough. When silvering face up, however, the solution must be kept in constant motion to prevent particles of precipitated silver from settling on the glass surface.

In a few minutes after mixing the bath turns a dark brown color, which, as the operator proceeds, gradually becomes lighter and lighter, until at length it is nearly clear again. At a temperature of 70° F., which is best for securing good results (if much lower than this the film will be too thin, and if much higher, too soft), the operation will be finished in from ten to fifteen minutes. The mirror is then lifted out, placed in an inclined position under a stream of clean water, and the whole surface rubbed vigorously with a pad of clean

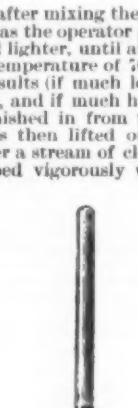


FIG. 1.

absorbent cotton until the white film on the surface of the silver is entirely removed and the whole surface is bright and clear. The mirror is finally set on edge on a sheet of blotting paper in a warm dustless place and allowed to dry. If the operation has been successful, a bright hard surface will be obtained which will need no polishing, and will, therefore, be free from the minute scratches always produced by the polishing pad, no matter how carefully the latter may be prepared and kept. One essential condition to success is the use of clean wash water, not necessarily distilled water, but water which is at least free from free alkalies and acids, and from any suspended sediment.

The foregoing process is of especial value where nondiffusive coats of silver are desired, for example, on concave mirrors of that form of Littrow spectroscope recently described by the author.*

When half silvering, i. e., when a very thin semi-transparent coat—such as is used on telescope objectives for solar observations, or on the "separating glass" of the "interferential refractometer"—is required, the old Rochelle salts process will give the most satisfactory results as regards uniformity, although the film is less enduring than that produced by the Brashear process. As the directions given in the books in regard to this process are generally meager and often misleading, the following notes on certain precautions necessary in order to insure success in this, the most difficult of all silvering operations, may be of service to those who have had but little experience in the art.

In the first place pure chemicals, while not absolutely essential, are yet of considerable advantage, and it is best to purchase them C. P. of some reliable

FIG. 2.

dealer in chemical supplies. If the ordinary silver nitrate and Rochelle salts of commerce are used, recrystallization is desirable. In making up the silver nitrate solution, great care should be taken to avoid an excess of ammonia by leaving the solution decidedly brown before filtering. In making up the reducing (Rochelle salts) solution I first bring the distilled water to boiling, and then add first the silver and then the Rochelle salts, both of which have previously been dissolved in the smallest possible quantity of boiling water. The boiling is then continued from twenty minutes to half an hour, or until the gray precipitate has collected together in the form of a compact powder at the bottom of the flask, leaving the supernatant liquid nearly clear. It should then filter perfectly clear and remain so after cooling. Much seems to depend on the length of time of this boiling; as regards the performance of the silvering bath, in general the longer the boiling, the more rapidly will the deposit take place and the more uniform it will be.

Cleaning the Glass for Silvering.—It may truly be said that no other one condition of success is one-half as important as a proper cleaning of the surface to be silvered. In four cases out of five a failure to secure good results is due to improper cleaning. The necessity for this is especially apparent in half silvering, for the deposit must here be absolutely uniform from the very beginning of the operation. Merely bathing the surfaces with acid, potash and alcohol in succession, as recommended in the books, is far from sufficient, unless the surface be unworked.† The best plan is to wash the surface thoroughly with a pad of absorbent cotton. Then rinse in clear water and transfer to a dish filled with strong nitric acid. Again go over the whole surface thoroughly with a pad of cotton held on the end of a bent glass rod of the form shown in Fig. 1. The surface must be rubbed hard, not merely lightly brushed over. If care is taken to flatten down and round over the end of the rod, as shown in the figure, and to pick out a piece of cotton free from any gritty particles, there will be no danger of injuring the surface. Then pour off the acid or transfer the glass to another dish filled with a strong potash solution, and repeat the rubbing. Finally rinse and place in a dish of pure distilled water until ready for silvering.

The use of the alcohol as recommended by the books is not only unnecessary but, unless the glass be very thoroughly washed subsequently, is actually detrimental. If any considerable amount of organic matter is present, it should be removed before commencing the cleaning, either by washing with alcohol or, better, by a bath of sulphuric acid to which some permanganate of potash has been added. For cleaning large mirrors, Mr. Brashear recommends that, after being treated with nitric acid and potash, the surface be rubbed with prepared chalk until it is thoroughly clean and dry. It is then either washed again with water or left dry as it comes from the chalk polishing until the silvering bath is ready.

When the surface is properly cleaned, the distilled water will wet and flow over the whole surface uniformly; if it is not, it will collect in drops on the plate. If it does this, the cleaning operations must be repeated.

It is essential that the utmost cleanliness be observed in all of these operations. They should be conducted preferably in glass or porcelain vessels, and the fingers should never be allowed to touch the surface which is to be silvered. If small, the plates are handled by means of glass tongs or supports, like those shown in Fig. 2. If the plate is large, it is necessary to use two of the latter, one on each side, or better to make a glass frame with two handles, similar to that shown in Fig. 3. For still larger mirrors, a glass dish with a

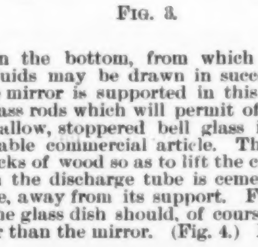


FIG. 3.

stopcock in the bottom, from which the different washing fluids may be drawn in succession, may be used. The mirror is supported in this case by means of small glass rods which will permit of perfect washing. A shallow, stoppered bell glass is perhaps the most available commercial article. This is supported on two blocks of wood so as to lift the central stopper, into which the discharge tube is cemented by means of paraffine, away from its support. For the sake of economy the glass dish should, of course, be but very little larger than the mirror. (Fig. 4.) In case mirrors

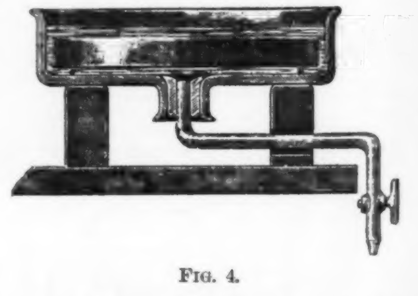


FIG. 4.

of irregular shapes are to be silvered, special dishes of just the right size may be made by roughly nailing together a box of wood of the required size and dimensions, and then thoroughly coating the inside with very hot melted paraffine. If the mirror be very large indeed, the most convenient as well as the most economical way is to let the surface to be silvered itself be the bottom of the silvering dish, and form the sides by passing around the edges of the mirror a strip of paraffined paper, which is held in place by a rubber band or cord. The paper is cemented to the edge of the mirror by rapidly passing a hot iron around the

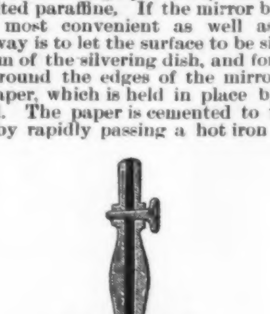


FIG. 5.

latter. A shallow dish is thus formed, which serves to hold the cleaning and finally the silvering fluid. Or by using care the band may be put in place after cleaning, and used only for the silver bath, since it is only this that needs to be economized.

If the mirror is to be silvered face downward—a method preferred by some because less care is necessary during the silvering—some method of support must be adopted which will lift the face about a centi-

* From the Zeitschrift fur Instrumentenkunde, January, 1895.

† English Mechanic, 1893; also in a pamphlet, "Silvered Glass Reflecting Telescopes and Specula," by J. A. Brashear; Best & Co., Pittsburg, Pa.

* "An Improved Form of Littrow Spectroscope," F. L. O. Wadsworth, Phil. Mag., July, 1894.

† It is a remarkable fact, which has probably been noticed by all who have had much silvering to do, that it is much more difficult to silver on a worked (i. e., ground, polished) surface than on one from which the natural blown surface has not been removed.

meter above the bottom of the silvering dish. In this case the method of support which I prefer, as more cleanly and less wasteful of space than any other, is the use of three wedge-shaped blocks of paraffined wood placed in the bottom of the silvering dish. When finished, the mirror is removed by placing the hand covered with a sheet of blotting paper on the back, and then inverting the dish. If the mirror is too heavy to be held in one hand, both may be used while an assistant inverts the dish. Another method, which I have never used, but which perhaps might be equally cleanly and efficient, would be the use of a suction clamp applied to the back of the mirror. (Fig. 5.)

To briefly recapitulate, the points essential to success in silvering are: (1) a thorough and systematic cleaning of the surface; (2) reasonably pure chemicals and a silver nitrate solution containing an excess of silver; (3) uniformity of temperature between the silvering bath and the mirror, preferably from 15° to 20° C.; (4) the use of clean water, and plenty of it, in all the stages of operation, especially in the final washing.

The methods of operation described in this paper are probably most of them already familiar to those who have had experience in this work. It is not for them that this paper is written, but for those who, because of inexperience, have had difficulty in securing uniformly good results. If it is of any service in assisting them to a knowledge of a better method (and I certainly consider Mr. Brashear's method far superior for general use to the old Rochelle salts process), or of more convenient ways of working, the object of the author will have been accomplished.

F. L. O. WADSWORTH.

ATMOSPHERIC ELECTRICITY.

PROF. SCHUSTER delivered recently a discourse on "Atmospheric Electricity" at the Royal Institution. He prefaced his remarks by discharging a couple of Leyden jars, stating at the time that every one who saw such an experiment must have been struck with the similarity between the spark discharge and lightning. Although Benjamin Franklin was not the first to perform the experiment, he was the first to show by definite means the relation which existed between electrical discharges in the atmosphere and the discharge of a Leyden jar. One of the experiments suggested by Franklin in 1749 was the erection of an arrangement resembling a sentry box on the top of a high building; in this a man was to stand, being insulated on a glass legged stool, and grasping a rod projecting skyward. Another individual, in connection with earth, was then to see if sparks could be obtained on bringing the knuckle of his hand near any part of the body of the animated lightning conductor. It is not apparent that Franklin anticipated any dangerous results from this experiment; at any rate we have no record that any such occurred. Although the thunderstorm is one of the best known examples of atmospheric electrical disturbance, it is by no means the only one.

To explain the theory of electrical discharge, according to modern ideas, the lecturer took a piece of elastic, and holding one end in each hand, pulled it out. His two hands then seemed to attract each other, due to the material under stress connecting them. In this way the modern theory of electricity, as expounded by Lodge and Rowland, was brought home to the habitues of the Institution in Albemarle Street. Although it is difficult to get rid of the idea of electricity "as a something," it is better to consider that it is not a something itself, but the manifestation of a something in between the charged bodies, which is under a stress or exhibits results of the nature of a stress. If the string or elastic referred to broke, then the analogy with an electric spark is complete. The something which breaks down cannot be ether, because if the air is got rid of, no spark would pass; the weak part of the chain has evidently some connection with air.

Atmospheric electricity had been noticed by observers from comparatively early times. It is especially marked in fine weather. The changes in intensity are shown in Fig. 1, in which the diurnal variations are

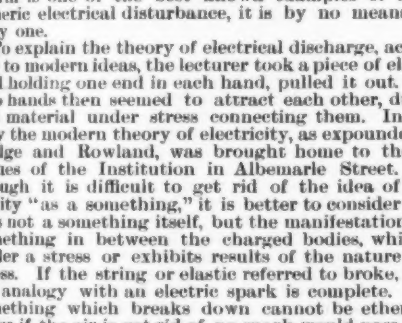


FIG. 1.—CURVE SHOWING DIURNAL VARIATIONS FOR WINTER AND SUMMER.

shown, as well as average curves for winter and summer. One of the earliest records of observations was made by an experimenter to whom the ether stress was evidenced by his hair standing on end, and he, in the true spirit of a scientific man, not only recorded the fact, but also the length of hair which stood on end; it was 4 inches. Prof. Schuster gave an illustration of the average field of force which is found at an ordinary height, by inserting a bank of lamps between two horizontal plates. These were apparently 100 volt lamps, and lit up brightly. Although in this experiment the analogy was complete, in practice the difficulty is to obtain measurements, because the bringing in of a body into the charged space disturbs the electrical field.

The question which is asked as soon as it is appreciated that lines of force start from the surface of the ground is, Where do they end? There is a theory that the lines of force pass outside the earth, and that the earth has been electrified for all time, but several causes are at work which, it is known, would tend to de-electrify it, should the foregoing theory as to initial electrification be accepted as true. Franklin was aware of the fact that heated air would conduct; the experiment is a common one, and Prof. Schuster repeated it by using an electroscope of aluminum foil leaves; these were caused to diverge by being charged, and on bringing a lighted match near them they collapsed. The lines of force gave way as soon as they passed through the flame. Electrified air discharges a charged body, and will not carry lines of force. These two facts were strikingly exemplified by the apparatus shown in Figs. 2 and 3 respectively. In Fig. 2 an insu-

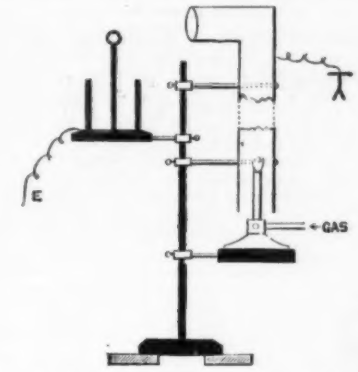


FIG. 2.—APPARATUS TO DEMONSTRATE THAT HEATED AIR WILL NOT CARRY LINES OF FORCE.

lated retort stand carries a Bunsen burner, which is lighted, and the products of combustion and heated air pass up the stovepipe in which the flame is set. The pipe has its upper end so placed that the heated air is discharged upon, or in the neighborhood of, the knob of a charged Leyden jar, also carried by the stand. The burner, pipe, and Leyden are insulated at the points of support, the pipe being connected to an electroscope, and the outside coating of the Leyden (to use Lord Kelvin's short term) is earthed. The electroscope does not, under normal circumstances, indicate the presence of a charge, but when the Bunsen burner is placed in position and the gas is ignited, it at once diverges, and on being discharged the leaves fall back only to rediverge, and so on. This shows the conductivity of heated air very clearly.

The second experiment is not quite so well known, and was quite as successful. In Fig. 3 the spark gap

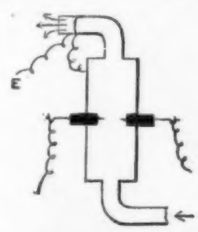


FIG. 3.—SPARK GAP.

of an induction coil is shown. The two spark pieces are connected to the secondary terminals of an induction coil, which, with the battery and spark gap, were at the Royal Institution covered by an earthed metallic case. Leading to and from the spark gap are two pipes. One is connected by rubber tube to a small foot blower, and the other was brought out opposite the knob of a Leyden. The Leyden was charged and connected to a lantern electroscope. On working the blower no marked effect was produced, but as soon as the coil was set in action and the air through which sparks had been passed was caused to impinge upon the knob of the Leyden, the electroscope leaves fell together, showing that air in this condition was also conducting. Prof. Schuster then remarked that this effect was shown on a large scale at Pontreschina, where the electric lighting mains were run overhead, and being in a mountainous district addicted to thunderstorms, were protected from lightning by dischargers as indicated by a wall diagram reproduced in Fig. 4. When minute

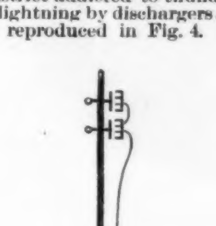


FIG. 4.—LIGHTNING PROTECTORS AT PONTRESCHINA.

sparks passed across the air gap of the discharger the dynamo current followed, and according to the speaker's experience, this led very often to a complete shut down of the lighting system. Sometimes the supply was resumed in a few minutes, at other times station plant was damaged, and an interruption took place lasting some time. We were under the impression that this fact was fully appreciated by electrical engineers, and that the Thomson-Houston, Westinghouse, and other manufacturers supplied dischargers arranged to free a system from excessive static charge, without permitting lightning to lead over the dynamo current. Mr. Wurts' recent work on this subject is pretty well known, and his latest recorded results show that an experimental demonstration of the breaking down of air need not be made at the cost of electric lighting companies.* The effect of heated air in conducting a discharge away harmlessly to earth may be taken to explain the immunity enjoyed by factory chimneys from damage by lightning.

To answer the questions, Where do the lines of force end? Do they reach out to the other planets or are they limited to the atmospheric envelope of this globe? Balloon and kite experiments have been made up to heights between 10,000 and 20,000 feet. Electrification apparently vanishes at a height of 12,000 feet, according to a recent carefully conducted experiment. Investigations of a like kind have shown that the diurnal variations which take place are uniform over the earth. These are stronger in winter than in summer.

Some recent observations at Vienna, and others made by a friend of Prof. Schuster during a voyage round the world, have led to some most interesting conclusions. It appears that the electrification of the atmosphere is connected with, not the amount of watery vapor in the air, but the aqueous vapor pressure. Fig. 5 shows a curve, one of four exhibited, connecting the volts per cm. with the vapor pressure. It is more

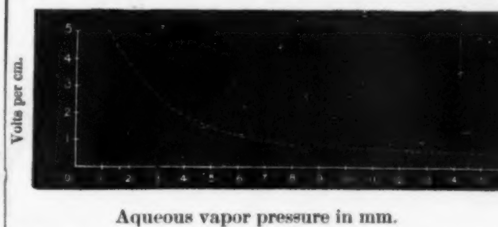


FIG. 5.—CURVE CONNECTING STRESS WITH AQUEOUS VAPOR PRESSURE AND SOLAR RADIATION IN THE ULTRA-VIOLET.

important, however, to find that a curve, deduced from the latter observer's measurements, plotted over the theoretical curve and connecting solar radiation with electrification, shows only small departures from the theoretical. If this be confirmed, then it follows that a more important relationship will be found to exist; some connection between the ultra-violet solar radiation and the amount of moisture in the air. Atmospheric electricity can therefore be best investigated by examining these effects. The lines of force seem to find their anchorage on small masses of matter. Dust storms are known to exercise an influence upon the sign and magnitude of electrification at different points. Thus a dust storm in Upper Egypt seemed to reverse the electrical effects in the center of Germany. Waterfalls cause a redistribution for many miles around, and no useful observations can be taken in a valley in which there are waterfalls. Figs. 6 and 7 show two diagrams used to illustrate the lines of force in direction and magnitude. Fig. 6 shows the principle

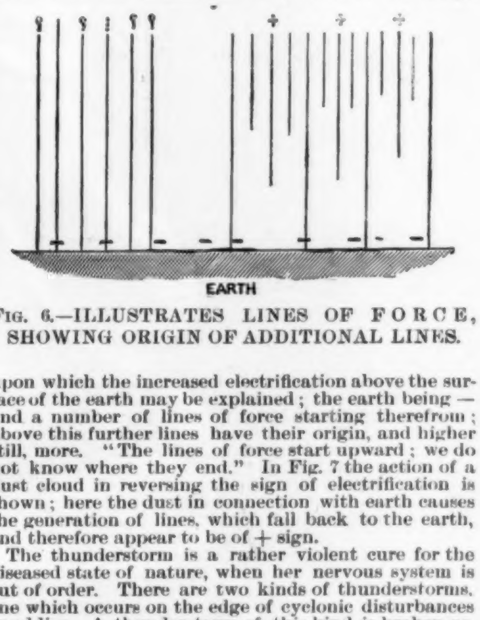


FIG. 6.—ILLUSTRATES LINES OF FORCE, SHOWING ORIGIN OF ADDITIONAL LINES.

upon which the increased electrification above the surface of the earth may be explained; the earth being — and a number of lines of force starting therefrom; above this further lines have their origin, and higher still, more. "The lines of force start upward; we do not know where they end." In Fig. 7 the action of a dust cloud in reversing the sign of electrification is shown; here the dust in connection with earth causes the generation of lines, which fall back to the earth, and therefore appear to be of + sign.

The thunderstorm is a rather violent cure for the diseased state of nature, when her nervous system is out of order. There are two kinds of thunderstorms, one which occurs on the edge of cyclonic disturbances or eddies. A thunderstorm of this kind is broken up in crossing a river, and may travel down one bank before breaking up. There is a great regularity in their behavior, and in the paths of discharge. Thus, of trees the oak is frequently struck, but the beech never,

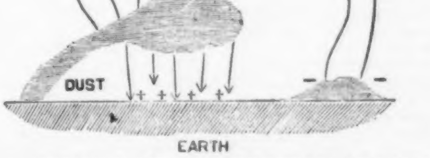


FIG. 7.—ILLUSTRATING REVERSAL OF LINES OF FORCE DUE TO DUST STORM.

or very seldom. Oily matter seems to be a peculiar protection against lightning, and this may explain why the latter is exempt. In a thunderstorm the safest course for a human being is to get wet through to be-

* Vide Electric Power, February, 1895. "Notes on Protection against Lightning." Collected during the summer of 1894, by Alexander Jay Wurts.

gin with. Franklin has recorded that he could kill a rat when dry by a lightning discharge, but when wet, never. Prof. Schuster exhibited the stocking worn by a friend of his while Alpine climbing; in it a large hole had been burned, but without bodily harm to the wearer. This was due to a discharge received through the body which, however, left no mark. The exact manner in which the mishap occurred was, however, not dwelt upon. St. Elmo's fire is another interesting evidence of atmospheric electricity. Its sign may be either + or —. Some of the Pontreschina breakdowns were stated to have been traced to this source, the actual thunderstorm being absent.

Between 1753 and 1886, 25 theories of atmospheric electricity have been proposed. The most fruitful year was 1884, when no less than five brand new theories appeared. The favorite causes cited are the earth's rotation and the energy radiated by the sun. The evaporation which goes on from all large bodies of water due to the heat of the sun is usually regarded as a leading cause. Prof. Schuster then illustrated the difficulty which attaches to certain problems; this may be summed up in the short question, How can we get into a sphere? Lenard's experiments on artificial waterfalls and the electrified air round a waterfall were mentioned. The fact that a cloud discharges rain during an electrical excitement has a bearing on the same question. Faraday found, for example, that ice and water rubbed together left a state in which the ice was positive and the water negative. Where clouds lie above a thunder cloud, it may be suggested that ice and water are practically in layers, and mutual friction will give rise to the separation of electrical charges.

The aurora borealis was the last manifestation of atmospheric electricity alluded to. This is, in England, usually seen at a height of 100 to 200 miles, but in Arctic regions much lower. The borealis is usually connected with the formation of cirrus clouds, and it appears regularly with the long cycle of eleven years. Its appearance, and the occurrence of spots on the sun, have been noted as taking place together. It is at a minimum in Greenland when at a maximum with us, and this appears to indicate that the belt favorable to its display suffers a displacement. After a brief reference to inter-planetary effects and diurnal variations, Prof. Schuster closed a most instructive discourse by expressing a hope that as another Antarctic expedition was being talked about, those who were able to control its work would see that due place was given to researches upon atmospheric electricity at high latitudes. "It is of more importance that a connected series of observations upon atmospheric electricity should be taken than that such an expedition should penetrate a few miles nearer the pole."—The Electrical Review.

GUSTAVE MICHEL'S "FLOWERS OF SPRING."

We present herewith an illustration of M. Gustave Michel's new bronze statuette, "Flowers of Spring," for which we are indebted to the Magasin Pittoresque. Of all the works of this talented French master, this statuette is the most ideal. It is a personification of spring, a dream of grace and beauty. M. Michel first became known as a sculptor in 1875, when he sent his Hebe to the Salon. He was then twenty-four years old. Among his other works are statues of Circe, Peace, Aurora, Thought, and a Sculptor Pursuing his Ideal. M. Michel is now engaged on some important works which will be exhibited in the Salon of 1896, and will attempt to awaken public interest in painted statues. Though still a comparatively young man, M. Michel has attained an enviable place among contemporary French sculptors.

"FLOWERS OF SPRING."

[From Science.]

ARGON.

The plain facts concerning argon are these: For some time past Lord Rayleigh has been engaged on refined work involving the weighing of various gases. Last year he found that the nitrogen obtained from the air is a little heavier than that made from definite chemical compounds. This led him to further experiments, and, at the same time, Professor W. Ramsay, of University College, London, also undertook experiments with the object of explaining, if possible, the discrepancy. The general method of work consisted in passing air, first through substances that have the power to remove those constituents that are present in small quantities, such as water vapor, carbonic acid gas, etc., then through a heated tube containing copper. The oxygen of the air unites with the heated copper, and what has hitherto been regarded as nitrogen remains uncombined. This "atmospheric nitrogen" was subsequently treated in three different ways for the purpose of removing the nitrogen from it.

(1) It was drawn through clay pipes in the hope that, if the gas is a mixture, one of the constituents would pass through the porous material more easily than the other, and at least a partial separation be thus effected. While something was accomplished in this way, the experiment was on the whole unsatisfactory.

(2) The "atmospheric nitrogen" was mixed with oxygen in a vessel containing caustic alkali, and electric sparks were passed through the mixture. Under these circumstances the oxygen united with nitrogen and formed a compound which is soluble in alkali. After no further absorption of nitrogen could be effected by sparking, any unchanged oxygen present was removed, and there was then found a residue of gas which was certainly not oxygen nor nitrogen. This proved to be the substance about which the world is now talking.

In this connection it is of great interest to note that Cavendish, in 1785, probably had this same substance before him free from nitrogen. He performed the experiment above described, and noticed the residue, and says in regard to it: "We may safely conclude that it is not more than $\frac{1}{120}$ of the whole." This is very nearly the truth as regards the relative amount of argon in the air.

(3) The most satisfactory method for obtaining the gas on the large scale consists in passing "atmosphere nitrogen" over highly heated magnesium, which has the power of uniting with nitrogen, while the newly discovered gas has not this power. But, even by this method, the preparation is very slow, and, up to the present, the gas cannot easily be obtained in large quantity.

The new substance is heavier than nitrogen. The density of hydrogen being taken as unity, that of nitrogen is 14, of oxygen 16, and of argon 19·7.

Perhaps the most remarkable property of argon is its inertness. It has not been possible thus far to get it to combine with any other substance, so that anything more than a general comparison with known substances is out of the question. It owes its name to its inertness, argon being derived from two Greek words signifying "no work."

A determination of the ratio of the specific heat of argon at constant pressure to that at constant volume was determined by means of observations on the velocity of sound in the gas, and the ratio was found to be 1·66. This is of much importance as showing that the particles of which the gas is made up act as individuals. If this conclusion is correct, it follows further that argon must be either a single element or a mixture of elements, and that, if it is a single element, its atomic weight must be nearly 40, as its density is 19·7 and its atom is identical with its molecule.

Professor Crookes has studied the spectra of argon, and, in an article giving his results in detail, he says: "I have found no other spectrum-giving gas or vapor yield spectra at all like those of argon." . . . "As far, therefore, as spectrum work can decide, the verdict must, I think, be that Lord Rayleigh and Professor Ramsay have added one, if not two members to the family of elementary bodies."

Finally, Professor Olszewski, of Cracow, the well known authority on the liquefaction of gases, has succeeded in both liquefying and solidifying argon. It was found to boil at 186·9° C., and to solidify at 189·6° C., forming a mass resembling ice.

To quote from Professor Ramsay's article read before the Royal Society: "There is evidence both for and against the hypothesis that argon is a mixture; for, owing to Mr. Crookes' observations of the dual character of its spectrum; against, because of Professor Olszewski's statement that it has a definite melting point, a definite boiling point, and a definite critical temperature and pressure; and because, on compressing the gas in presence of its liquid, pressure remains sensibly constant until all gas has condensed to liquid."

The above is a brief account of all that is known about argon, and it would evidently be premature to indulge in speculation regarding its position in the system. It may as well be said at once that, if it is an element or a mixture of elements, it will apparently be difficult to find a place for it on Mendeleeff's table. It will be well to await developments before worrying on this account. If the time should ever come when Mendeleeff's table has to be given up, something better will take its place.

The suggestion has been made repeatedly that argon is perhaps an allotropic form of nitrogen. The strongest argument against this view is the established fact that the gas conducts itself as if made up of individual particles, while any allotropic form of nitrogen, which is heavier than this, must, according to all that we know of such matters, consist of more complex molecules than nitrogen itself.

Ira Remsen.

Johns Hopkins University.

EXPLOSION DUE TO SODIUM, AND THE ST. PANCRAS EXPLOSIONS.

The origin of the recent explosions in street boxes used in connection with the electrical supply of the St. Pancras district, London, has at length been traced to its source—at least an explanation of the matter has now been offered by Major Cardew, the electrical adviser of the Board of Trade, which most scientists would admit as a very reasonable one, in view of the facts ascertained. He has discovered a remarkable deposit on some of the insulators, which, on investigation, was found to contain a considerable quantity of the metal sodium. This metal, under certain conditions, becomes highly inflammable on contact with water, and it is believed that on ignition it fired the escape coal gas found in the street boxes; hence the explosions. Sir Courtenay Boyle, on behalf of the Board of Trade, states that it devolves upon his department, without delay, to investigate the causes of the deposit of the sodium, with a view to its prevention. The matter is, in official circles, regarded as of such a pressing nature and to present such difficulty from a scientific point of view that the assistance of the Royal Society and of the Institution of Electrical Engineers was at once invoked on the discovery

being made. The Board of Trade has apparently made up its mind that other similar explosions that have recently happened in the metropolis are due to the same cause, and their prompt action is to be highly commended.

In the mean time, in order to prevent, as far as possible, the recurrence of explosions, the Board of Trade strongly urged the St. Pancras Vestry to provide a thorough system of ventilation for the conduits and street boxes, to reduce the space in the boxes within which an accumulation of gas could occur, and to make a thorough inspection of the mains, and remove the deposit from the insulators wherever it was found to exist. This has now been done, so far as the St. Pancras district is concerned, but we do not gather that other metropolitan bodies in charge of electric lighting arrangements have been counseled to do likewise, so that the danger still lurks in our midst pending the inquiry of the scientists concerned, which may be a very protracted one.

This seems a seasonable opportunity to make a few remarks on sodium, the special properties of which do not seem to be generally understood, though it would naturally be impossible, except by means of a very tedious and careful examination, to throw much light on the actual cause of its disposition on the insulators referred to. Sodium is a chemical element; but it occurs nowhere in nature in an uncombined condition.

It was first discovered by Sir Humphry Davy, almost immediately after that celebrated man had discovered potassium, and by the same means, viz., by exposing a piece of moistened hydrate of soda to the action of a silicon. By the invention of what is known as the Castner process a new method came into existence. This consists in reducing either the hydrate or the carbonate of sodium in a fused state by means of "carbide" of iron or its equivalent, a mechanical mixture of carbon and iron so intimate that the two substances can be separated only by aid of acids or intense heat. In the Minet process of producing aluminum, a mixture of the fluoride of aluminum and sodium together with the chloride of sodium is submitted to the influence of the electric current. On this, the sodium fluoride undergoes decomposition by the action of the electric current yielding up its sodium by interaction with the aluminum fluoride present, thus causing the liberation of an equivalent of aluminum and reforming sodium fluoride. The metal, cast into the form of cakes, or ingots, is protected from the air by a coating of paraffin, and secured in closely fitting soldered-up tinned iron boxes and in other ways.

From the foregoing it will be seen that sodium, like other chemical elements, may be derived from its compounds by the application of electricity; and, indeed, that was how it was first discovered. Then, it will be noticed that under certain circumstances on being introduced to water it causes violent explosions. If the presence of gas had not been ascertained to have existed in the street inspection boxes, and the insulators had a thick coating of the metal, minor explosions might well have been attributed to the explosive action of the sodium alone. We have no means of ascertaining the precise amount of the metal which was proved to occur, so it is dificult to form any definite opinion. with the aid of his friends at home had managed to make some progress in arithmetic and to acquire a very slight theoretical knowledge of our language. He seemed to understand a little ordinary conversation, and learned easy lessons in history and geography by having them read to him. He would attempt to talk and recite in school, but his teachers had to guess, for the most part, at the meaning of his jargon. For myself I do not recall a single word that was at all intelligible. The first time he came to my office he could not make the conductor on the train understand the name of the station at which he lived, and after frequent attempts he was obliged to write it out, which he could do very imperfectly, for his spelling was almost as bad as his speech.

With a history of this kind, and being deprived of that greatest of all means of mental development—speech—you will be prepared to believe that he had acquired a reputation, even among those who knew him best, for listlessness and stupidity. Indeed, his aunt, with whom he came, had given up all hope of making anything of him; but the boy, discouraged as he was, seemed determined to make one more effort, and he was thoroughly in earnest.

Upon examination of his vocal and speech organs I found only a slight post-nasal catarrh and some little hypertrophy of the faucial tonsils. Of course, I thought immediately of the probability of his being tongue-tied, but his aunt assured me that there was nothing of the sort. I found, however, that he could protrude the tip of the tongue scarcely beyond the outer margin of the lips. The tip seemed a full inch or more too

DESIGN FOR A FIREPLACE.—From Moderne Innen-Decoration.

powerful voltaic battery, the alkali being put between a pair of platinum plates connected with the battery.

When placed upon the surface of cold water it decomposes it with violence, but does not ignite the hydrogen liberated, unless the motion of the sodium be restrained, when the cooling effect is much less; but the hydrogen is lighted on the sodium being placed in hot water. In a state of rest, on the application of water, the reaction is more dangerous than the corresponding phenomena developed by potassium, because it frequently leads to most violent explosions. This point is to be especially noticed. The metal does not affect carbonic oxide at any temperature. Its fusing point is 95·6° C.; specific gravity 0·98; before the blowpipe it gives a strong yellow flame. When pure it is of a silver white (almost white) tint, and is so soft at ordinary temperatures that it may be easily cut with a knife or pressed between the finger and thumb; while it oxidizes rapidly in the air. Sodium combined with silica is present in small quantity in most silicates. In union with chlorine, as common salt, it is the most important mineral ingredient of sea water, and can be detected in minute quantities in air, rain and river water. As might naturally be supposed, it is, as a constituent of the atmosphere, more abundant on or near the sea coast than inland. The proportion in London air is so minute that the deposit on the insulators can hardly have been derived from that source.

Metallic sodium was for years manufactured by reducing sodium carbonate, or soda ash, by means of charcoal or other form of carbon. It is used in the preparation of aluminum, magnesium, boron and No doubt, the Board of Trade will publish full particulars concerning that later on. Inquiry should, we think, be directed, in the first place, to the precise nature of the insulators. In the preparation of porcelain goods of a certain class it is customary to glaze the exterior by the application of common salt; the chloride might indirectly have provided some of the sodium in presence of a very powerful electric current. If dirt had been allowed to accumulate to any extent, this also might have been partly responsible; the actual composition of the electric mains themselves might show that adulteration had been at work; but these were mere suggestions which a careful inquiry would at once set at rest.—The Builder.

AN INTERESTING CASE OF TONGUE TIE.*

By G. Hudson Makuen, M.D., Philadelphia.

The patient whom I shall show you this evening is nineteen years of age, a farmer by occupation, and up to within eleven months he has been utterly unable to use articulate speech in a manner which could be understood. He had been examined by local physicians and had been made to believe that his trouble was of central or cerebral origin, and that nothing could be done for him. The feeling that he was thus cut off from this chief means of communication with his fellows had completely disheartened him.

He had attended public school with other boys, and

* Read before the Philadelphia County Medical Society, February 13, 1895.—Med. and Surg. Reporter.

short, and, strange to say, the frænum did not appear to be a very decided factor in holding it down or back, for in his attempts to protrude the tongue the frænum was not greatly stretched. The trouble seemed to be a muscular one, and this I believe to be the case. The anterior fibers of the geniohyoglossus muscle were too short, and prevented not only the protrusion of the tongue, but any other free action of that member. He could elevate the back part of the tongue and make the hard G sound or the NG sound, but he could make no sound whatever which required the placing of the tip of the tongue to the roof of the mouth or the upper teeth. He made the K sound for T and hard G sound for D. As an example, he said "ik" for "it," and when I asked about his parents he said they were "gay"—meaning that they were dead. Furthermore, there seemed to be no method in his speech; it was a mere jumbling of inarticulate and unintelligible sounds, and the expression of his face was in perfect harmony with his speech—vacant, staring, meaningless.

The boy being somewhat delicate, and his friends being decidedly opposed to operative measures, and the cause of the trouble being doubtful, I decided to study the case carefully before giving an opinion or recommending methods of treatment. I gave him some vocal exercises for a few days and watched the results, after which I clipped the frænum of the tongue well back.

I then put him in the hands of a teacher, who gave him under my direction several hours' vocal drill each day for several months, during which time he made considerable improvement in sounds and words which

did not require free action of the tip of the tongue. By this time I was convinced that the trouble was entirely a local one, and that the boy was of more than average intelligence and well worth developing. I then decided to divide the anterior fibers of the genio-hyoglossus muscle, and thus try to give to the tongue the necessary freedom of action. His people would not give their consent to etherization, for they were skeptical as to favorable results from any measures whatever. The boy, however, was desperate, and would submit to anything which promised relief. We took the matter into our own hands, therefore, and with cocaine anesthesia I made an incision under the tongue of three-quarters of an inch in the anteroposterior direction, and one and one-half inches from side to side. There was considerable bleeding, which was easily controlled, and, of course, there was also some pain.

He came to my office each morning for five days thereafter, and I broke up little adhesions which had formed and practiced slight lingual traction. On the morning of the sixth day he came in a great state of excitement, and with much pain, which he referred to the region of his tongue and throat. The tongue was greatly swollen, filling the entire mouth and protruding between the lips. He had a temperature of 103°. The larynx became involved to the extent of threatening suffocation, and I thought it would surely be necessary to open the trachea, which I made all preparations to do, but after succeeding in giving him a brisk purge the inflammation gradually subsided and the breathing became less labored. He was confined to bed for ten days, after which time he practiced frequent lingual traction and vocal exercises directed toward a free action of the tongue. His improvement from this time on has been most wonderful. Here we have a young man, nineteen years of age, who less than a year ago could not pronounce intelligibly more than three words of our language, could not buy a morning paper or tell you where he lived, and could not give his name to save his life. What he can do to-day, with your permission, Mr. President, I shall try to demonstrate to you. I shall ask him to recite in your hearing Brutus' speech against Cæsar.

BRAIN SURGERY FOR IDIOTS.

IN the New York Post-Graduate Hospital, recently, a heroic cure was tried on two little babies who had been born idiots. One of New York's surgeons, Dr. Seneca D. Powell, performed on them the operation of craniotomy, which consists in taking out a piece of skull bone from the top of the head, in the hope that the cramped brain will expand and grow enough to change its possessor from a creature possessing less than the intelligence of an animal into a being that has at least enough reason to attend to its own wants.

Tiny and puny as Dr. Powell's little patients were, they recovered wonderfully and quickly after the severe operation, and soon after they were both sleeping quietly with every chance of being up and about in a few days.

In a cot near them lay another little girl, who had also been an absolute idiot from birth and who had been operated on some time ago. Before that, she had been a creature so devoid of even the least spark of intelligence that her condition seemed absolutely hopeless. She was sitting up when seen, held out her hand when asked to shake hands, and even tried to talk. The doctors said that she would never be more than just intelligent enough to care for herself, but even that change is a wonderful one.

The babies who were operated one were both boys, each a little over two years old. Their names were respectively Alphonso and Abraham. Alphonso was taken first. His pinched little face was so unhumanlike, and even unanimal-like, that it created a feeling akin to horror. The pitiable, expressionless eyes stared into vacancy and no line in his face responded to the coaxing and fondling of the nurse while she prepared him for the operation.

First the scalp was completely and carefully shaved, then the child was put under the influence of ether, and so carried into the operating room, where Dr. Powell was waiting with his electrical saw (his own invention), and the usual shining array of instruments, vessels of antiseptic solution and jars of iodoform and rubber bandages. As soon as the baby was brought in it was laid on the table, its head resting on a sand bag and held firmly by two assistants. Then a long strip of muslin was bound as tightly as it could be drawn around the upper part of the head, just above the ears and eyebrows. Several wrappings of this were made and then it was tightened still more firmly by an adhesive rubber bandage. The object of this was to prevent any great loss of blood.

A spray of bichloride of mercury wash was then turned on, and Dr. Powell, with a stout knife, made a long cut down the center of the head, beginning behind the forehead and ending well behind the crown. Quickly the scalp was laid back till the left half of the skull was exposed, and in another instant the trephine was at work. Trephining or trepanning is an ancient operation. The trephine is practically an auger, which is used with a semi-rotating motion, until a tiny round disk is cut out of the skull. Four trephine openings were thus made in the idiot's skull, as shown in cut No. 1.

Up to this time the work had been done with marvelous celerity. Now the fingers of the surgeon and his assistants moved even more rapidly.

Hardly had the trephine been withdrawn from the fourth and last opening before an assistant handed the surgeon a long, broad strip of silver. This was thrust gently into one of the openings and worked along between the brain and the skull till it protruded from the next hole, thus forming a metal shield between the brain and the skull and obviating all danger of accident should the saw slip.

As soon as the shield was in position an assistant started the electric battery, which communicated motion to the circular saw. The latter is a little round instrument, not much larger than a tape measure, and it revolves like lightning. It has a guard, which is adjusted so to the thickness of the skull that there is absolutely no danger of cutting into the brain, even should the metal shields not be properly adjusted.

A sharp, spitting sound was heard for a second, and when the surgeon lifted his hand there was a long, fine cut clear through the skull, from one trephined hole to the other. The next cut was made about one-eighth of an inch from the first, and when it was finished a long, smooth, cut piece of bone came away, leaving the brain cavity exposed as shown in cut No. 2.

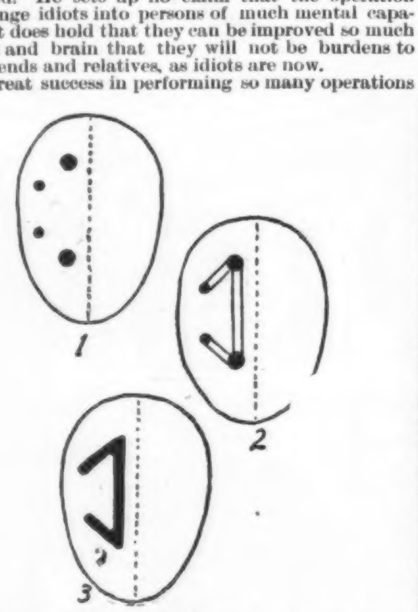
Quickly the shield was shifted, two more cuts were made with the saw, again there came the dexterous insertion of the shield into the remaining opening, and in less than five minutes after the saw was first applied the operation was complete. Two sharp corners of skull where the various incisions were removed, and in another instant the flaps of scalp were drawn back and stitched. Then a mass of fluffy bandages and cotton was placed over the skull, and the patient was carried into the ward. The whole operation, from the time the child was brought to the table till it was carried out, had lasted scarcely twenty-five minutes.

The next operation was performed even more swiftly. This boy, Abraham, had been operated on before, but owing to peculiar conditions, it was thought advisable to try it again. As the first attempt had been made on the left side of the head, the second operation was performed on the right side. The second case was remarkably free from excessive bleeding, and the child did not suffer at all from shock, in marked contrast to the first patient, who seemed at the end of the operation to be on the verge of collapse. After an hour, however, both children were doing equally well.

The latter and final operation was the nineteenth of this kind made by Dr. Powell, and of them all, he has lost only one case. Before he began working he explained to the doctors who gathered to watch him that he himself would undertake no responsibility for the success of the operations so far as mental brightening was concerned.

"I am only the surgeon. I perform the operation for which the patients are sent to me," he said. Despite this statement, however, Dr. Powell says that he thinks the operation has come to stay, and that of the cases which he has thus treated, at least thirty, and possibly forty per cent. have been wonderfully improved. He sets up no claim that the operation will change idiots into persons of much mental capacity, but does hold that they can be improved so much in mind and brain that they will not be burdens to their friends and relatives, as idiots are now.

The great success in performing so many operations



THE LATEST THING IN SKULL SURGERY.

of this kind with almost no mortality, as compared to the forbidding percentage of deaths resulting from the same attempts in Europe, is ascribed to the careful avoidance of anything that might produce shock. The usual method employed in craniotomy has been to cut out the bone with a punch which is virtually a conductor's punch, being different only in the cutting portion from the common tool. That method was so extremely jarring to the brain that the resultant shock nearly always killed the patient. Then a French surgeon designed an electrical circular saw, which, however, as it had the battery attached to it as one of its component parts, weighed twenty-five or thirty pounds and made delicacy of operation impossible.

The knowledge that shock to the brain made the process almost useless set Dr. Powell to designing a new instrument, and the result was the wonderful little saw used now. The electrical motive power is entirely separated from it, being transmitted through a wire to the saw itself; the latter weighing less than an ounce, can therefore be used as delicately as a scalpel. This and the shield have made the new operation possible.—The Press.

[Continued from SUPPLEMENT, No. 1005, p. 16070.]

THE INQUISITION IN MEXICO.

THE next morning (daylight being come) I perceived by the sun rising what way to take to escape their hands, for when I fled I took the way into the woods upon the left hand, and having left that way that went to Mexico upon my right hand, I thought to keep my course as the woods and mountains lay still direct south as near as I could; by means whereof I was sure to convey myself far enough from that way which went to Mexico. And as I was thus going in the woods I saw many great fires made to the north not past a league from the mountain where I was, and travelling thus in my boots, with mine iron collar about my neck, and my bread and cheese, the very same forenoon I met with a company of Indians which were hunting of deer for their sustenance, to whom I spake in the Mexican tongue, and told them how that I had of a long time been kept in prison by the cruel Spaniards, and did desire them to help me file off mine iron collar, which they willingly did, rejoicing greatly with me that I was thus escaped out of the Spaniards' hands. Then I desired that I might have one of them to guide out of those desert mountains towards the south, which they also most willingly did, and so they brought me to an Indian town eight leagues distance from thence named Shalapa, where I stayed three days; for that I was somewhat sickly. At which town (with the gold that I had quilted in my doublet) I bought me an horse of one of the Indians, which cost me six pezoes, and so travelling south within the space of two leagues I happened to overtake a Grey Friar, one that I had been familiar withal in Mexico, whom then I knew to be a zealous, good man, and one that did much lament the cruelty used against us by the Inquisitors, and truly he used me very courteously; and I, having confidence in him, did indeed tell him that I was minded to adventure to see if I could get out of the said country if I could find shipping, and did therefore pray him of his aid, direction, and advice herein, which he faithfully did, not only in directing me which was my safest way to travel, but he also of himself kept me company for the space of three days, and ever as we came to the Indians' houses (who used and entertained us well), he gathered among them in money to the value of twenty pezoes, which at my departure from him he freely gave unto me.

So came I to the city of Guatemala upon the South Sea, which is distant from Mexico about 250 leagues, where I stayed six days, for that my horse was weak, and from thence I travelled still south and by east seven days' journey, passing by certain Indian towns until I came to an Indian town distant from Mexico direct south 309 leagues. And here at this town inquiring to go to the port Cavallos in the north-east sea, it was answered that in travelling thither I should not come to any town in ten or twelve days' journey; so here I hired two Indians to be my guides, and I bought hens and bread to serve us so long time, and took with us things to kindle fire every night because of wild beasts, and to dress our meat; and every night when we rested my Indian guides would make two great fires, between the which we placed ourselves and my horse. And in the night time we should hear the lions roar, with tigers, ounces, and other beasts, and some of them we should see in the night which had eyes shining like fire. And travelling thus for the space of twelve days, we came at last to the port of Cavallos upon the east sea, distant from Guatemala south and by east 200 leagues, and from Mexico 450 or thereabouts. This is a good harbour for ships, and is without either castle or bulwark. I having despatched away my guides, went down to the haven, where I saw certain ships laden chiefly with canary wine, where I spake with one of the masters, who asked me what countryman I was, and I told him that I was born in Granada, and he said that then I was his countryman. I required him that I might pass home with him in his ship, paying for my passage; and he said yea, so that I had a safe conduct or letter testimonial to show that he might incur no danger; for, said he, "it may be that you have killed some man, or be indebted, and you would therefore run away." To that I answered that there was not any such cause.

Well, in the end we grew to a price that for 60 pezoes he would carry me into Spain. A glad man was I at this good hap, and I quickly sold my horse, and made my provision of hens and bread to serve me in my passage; and thus within two days after we set sail, and never stayed until we came to the Havana, which is distant from port de Cavallos by sea 500 leagues, where we found the whole fleet of Spain, which was bound home from the Indies. And here I was hired for a soldier, to serve in the admiral ship of the same fleet, wherein the general himself went.

There landed while I was here four ships out of Spain, being all full of soldiers and ordnance, of which number there were 200 men landed here, and four great brass pieces of ordnance, although the castle were before sufficiently provided; 200 men more were sent to Campechy, and certain ordnance; 200 to Florida with ordnance; and 100 lastly to St. John de Ullua. As for ordnance, there they have sufficient, and of the very same which was ours which we had in the Jesus, and those others which we had planted in the place, where the Viceroy betrayed Master Hawkins, our general, as hath been declared. The sending of those soldiers to every of those posts, and the strengthening of them, was done by commandment from the King of Spain, who wrote also by them to the general of his fleet, giving him in charge so to do, as also directing him what course he should keep in his coming home into Spain, charging him at any hand not to come nigh to the isles of Azores, but to keep his course more to the northward, advertising him withal what number and power of French ships of war and other Don Anthony had at that time at the Tercera and isles aforesaid, which the general of the fleet well considering, and what great store of riches he had to bring home with him into Spain, did in all very dutifully observe and obey; for in truth he had in his said fleet 37 sail of ships, and in every of them there was as good as 30 pipes of silver, one with another, besides great store of gold, cochineal, sugars, hides, and Cana Fistula, with other apothecary drugs. This our general, who was called Don Pedro de Guzman, did providently take order for, for their most strength and defense, if needs should be, to the uttermost of his power, and commanded upon pain of death that neither passenger or soldier should come aboard without his sword and harquebuse, with shot and powder, to the end that they might be the better able to encounter the fleet of Don Anthony if they should hap to meet with them, or any of them. And ever as the weather was fair, this said general would himself go aboard from one ship to another to see that every man had his full provision according to the commandment given.

Yet to speak truly what I think, two good tall ships of war would have made a foul spoil amongst them, for in all this fleet there were not any that were strong and warlike appointed, saving only the admiral and vice-admiral. And again, over and besides the weakness and ill-furnishing of the rest, they were all so deeply laden, that they had not been able (even if they had been charged) to have held out any long fight. Well, thus we set sail, and had a very ill passage home, the weather was so contrary. We kept our course in manner north-east, and brought ourselves to the height of 42 degrees of latitude, to be sure not to meet with Don Anthony his fleet, and were upon

our voyage from the 4th of June until the 10th of September, and never saw land till we fell with the Arenas Gordas hard by St. Lucar.

And there was an order taken that none should go on shore until he had a licence; as for me, I was known by one in the ship, who told the master that I was an Englishman, which (as God would) was my good hap to hear; for if I had not heard it, it had cost me my life. Notwithstanding, I would not take any knowledge of it, and seemed to be merry and pleasant that we were all come so well in safety. Presently after, licence came that we should go on shore, and I pressed to be gone with the first: howbeit, the master came unto me and said, "Sirrah, you must go with me to Seville by water."

I knew his meaning well enough, and that he meant there to offer me up as a sacrifice to the Holy House. For the ignorant zeal of a number of these superstitious Spaniards is such that they think that they have done God good service when they have brought a Lutheran heretic to the fire to be burnt; for so they do account of us. Well, I perceiving all this, took upon me not to suspect anything, but was still jocund and merry, howbeit I knew it stood me upon to shift for myself. And so waiting my time when the master was in his cabin asleep, I conveyed myself secretly down by the shrouds into the ship boat, and made no stay, but cut the rope wherewithal she was moored, and so by the cable hailed on shore, where I leapt on land, and let the boat go whither it would. Thus by the help of God I escaped that day, and then never stayed at St. Lucar, but went all night by the way which I had seen others take towards Seville. So that the next morning I came to Seville, and sought me out a workmaster, that I might fall to my science, which was weaving of taffaetas, and being entertained I set myself close to my work, and durst not for my life once to stir abroad, for fear of being known, and being thus at my work, within four days after I heard one of my fellows say that he heard there was great inquiry made for an Englishman that came home in the fleet. "What, an heretic Lutheran (quoth I), was it? I would to God I might know him. Surely I would present him to the Holy House." And thus I kept still within doors at my work, and feigned myself not well at ease, and that I would labour as I might to get me new clothes. And continuing thus for the space of three months, I called for my wages, and

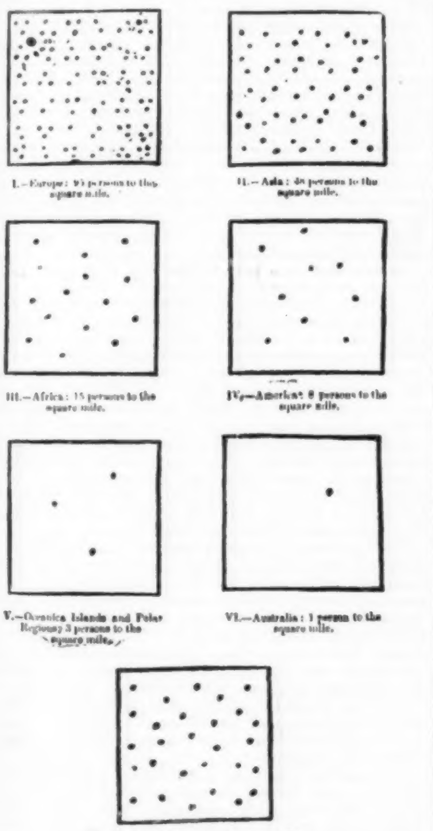


Fig. 1.—These seven squares show the density of population of the world; illustrated by the number of persons to each square mile of the various continents, etc.

bought me all things new, different from the apparel that I did wear at sea, and yet durst not be over bold to walk abroad; and after understanding that there were certain English ships at St. Lucar, bound for England, I took a boat and went aboard one of them, and desired the master that I might have passage with him to go into England, and told him secretly that I was one of those which Captain Hawkins did set on shore in the Indies. He very courteously prayed me to have him excused, for he durst not meddle with me, and prayed me therefore to return from whence I came. Which then I perceived with a sorrowful heart, God knoweth, I took my leave of him, not without watery cheeks. And then I went to St. Mary Port, which is three leagues from St. Lucar, where I put myself to be a soldier in the King of Spain's galleys, which were bound for Majorca and coming thither in the end of the Christmas holidays I found there two English ships, the one of London, and the other of the west country, which were ready freighted, and stayed but for a fair wind. To the master of the one which was of the west country went I, and told him that I had been two years in Spain to learn the language, and that I was now desirous to go home and see my friends, for that I lacked maintenance, and so having agreed with him for my passage I took my shipping. And thus, through the providence of Almighty God, after sixteen years' absence, having sustained many and sundry great troubles and miseries, as by this discourse appeareth, I came home to this my native country in England in the year 1582, in the month of February in the ship called the Landret, and arrived at Poole.

POPULATION OF THE EARTH, IN DIAGRAM.

IF Carlyle's cynical remark about the population of England—"twenty million, mostly fools"—holds for all the world, the number of fools left, despite the law of the survival of the fittest, is painful to contemplate. To help our feeble finite minds to grasp the situation, J. Holt Schooling, fellow of the Royal Statistical Society of England, has pictured out for us, in a series of interesting diagrams, the comparative populations of various countries both now and in the centuries to come. His article (Strand Magazine, February) opens with the following estimates of population:

In 1874, according to	Behm and Wagner	1,391	millions.
" 1878, "	Levasseur	1,439	"
" 1883, "	Behm and Wagner	1,434	"
" 1886, "	Levasseur	1,483	"
" 1891, "	Wagner and Supan	1,480	"

This last estimate he takes to be sufficiently accurate

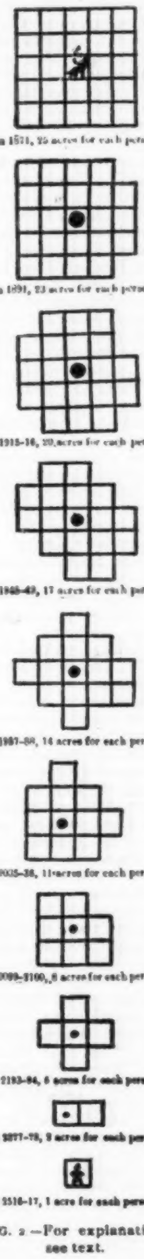


FIG. 2.—For explanation see text.

for a working basis. The population is divided as follows:

	Population.
Asia	825,954,000
Europe	357,379,000
Africa	163,953,000
America	121,713,000
Oceanic Islands and Polar regions	7,500,400
Australia	3,230,000
The world	1,479,729,400

Estimating the ratio between area and population in these different divisions, he secures the series of diagrams (Fig. 1) showing density of population. He turns next to the relations between area and population in the centuries to come, and after careful computation determines that the increase in the world's population is 5 per 1,000 persons per annum. The results work out as follows:

In 1891	1,480	million	persons.
" 1900 there will be	1,549	"	"
" 1950 " "	1,986	"	"
" 2007 " "	2,548	"	"
" 2030 " "	2,960	"	"
" 2100 " "	4,197	"	"
" 2200 " "	6,910	"	"
" 2300 " "	11,379	"	"
" 2400 " "	18,738	"	"
" 2516 " "	33,418	"	"
" 2517 " "	33,586	"	"

These figures are made the basis for another series of diagrams (Fig. 2), which he explains as follows:

"The dot in the center of each of these diminishing estates (except two) represents the gradually thinning owner, who is wise enough to lessen his requirements—and his bulk—as his estate grows smaller and smaller; the two little figures in the top and bottom 'estate' suggest a possible change of ownership during the six hundred and forty-five years of change to which the ten diagrams in No. 4 relate—i. e., from A. D. 1871 to A. D. 2516. Long before this latter date our descendants will probably be living in the air, or perhaps in the sea for a change, so that the lessening of space illustrated will not cause real inconvenience. Moreover, . . . one acre for one person is not a bad allowance. Belgium is now very nearly as crowded as this, and she yet finds room for all her manufactories and works, not to mention the ground space of the recent Antwerp Exhibition."

Taking Europe by itself, the writer then computes the density of population of the various countries and embodies these results in another series of diagrams (Fig. 3). He closes the article by unceremoniously packing all the teeming millions on the face of the earth into a cubic box (in diagram) 1,140 yards in width, 1,140 yards in length, and 1,140 yards in depth, and labeling it "Handle with care."—Literary Digest.

OUR SOLAR SYSTEM.*

By ALFRED BICKNELL.

I WISH to call your attention at some length to the magnitude of the solar system and the relative situation of the sidereal heavens. To comprehend such enormous distances as those which separate us from the nearest of the fixed stars is, in an absolute sense, an impossibility. The human mind is not large enough to grapple successfully with the mighty problem involved. A long array of figures carries with it no definite idea of the actual distance which they represent. But we may show some device, perhaps, which will help in considering the matter.

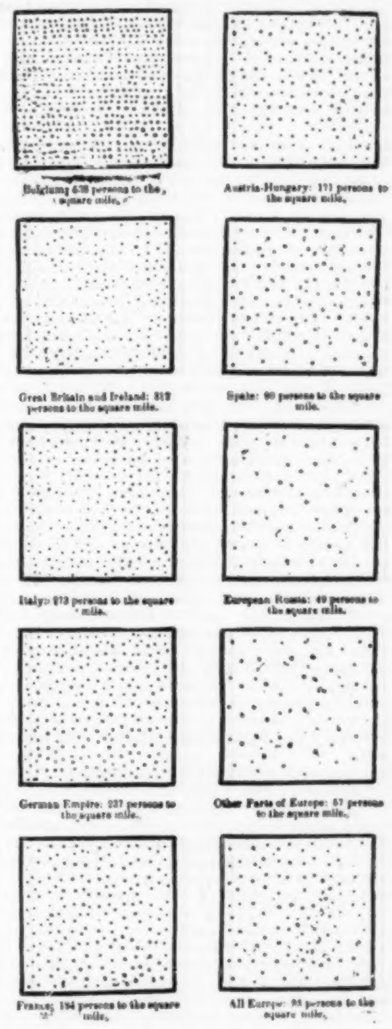


Fig. 3.—These ten squares show the density of population in Europe; illustrated by the number of persons, i. e., dots to each square mile of the various countries named.

Suppose a map of these United States were drawn on a space not larger than your thumb nail. On such a map the commonwealth of Massachusetts would be but a speck and yet relatively the map would be correct. So we may represent the solar system, approximately. In constructing maps and plans, a certain scale is used—as so many feet or miles to an inch. Now, using only round numbers, which are sufficiently accurate for our purpose, we say that the planet Neptune, the outermost known member of our system, is 2,800,000,000 miles from the sun. So if we use a line twenty-eight feet long, each single foot will represent one hundred million miles. On such a scale it would require a powerful microscope to see a map of the United States at all. But we put a bead at each end of this line, one representing the sun, the other Neptune. Between the two, other beads will represent the other planets. One nearly four inches from that representing the sun will be Mercury; about seven

* Read before the Parker Memorial Science Class.—Boston Commonwealth.

inches, Venus; eleven inches, the earth; seventeen inches, Mars; about five feet, Jupiter; nine feet, Saturn; eighteen feet, Uranus; with Neptune at the end.

This device shows approximately the relative distances of the principal planets from the sun. The asteroids lying between Mars and Jupiter are not represented, neither are any of the twenty-odd moons belonging to the system. To represent the size of the planets is not practicable. On this scale of one hundred million miles to one foot, a small shot would be large enough to represent the sun. As the sun is one thousand times as large as Jupiter, the giant of the system, itself one thousand times as large as this earth, you can understand that any object small enough to represent a planet could only be seen by the aid of a powerful microscope. On this scale a circle fifty-six feet in diameter would include the orbits of every member of the solar system.

When we look up at the stars on a clear night, the vast majority of objects in sight are suns, many of them much larger than our own sun. To ordinary eyesight, with a clear horizon, about fifteen hundred are seen at one time. How far from us are they? On this scale of 100,000,000 miles to one foot, the nearest would be about seventy miles. The approximate distance of only about twenty are known. As already stated, the attempt to give their distances in miles is meaningless. And the distance of only a small fraction is even approximately known. In the present state of knowledge it cannot be. Our measuring devices are not equal to the task. As well try to measure the ocean with a pint dipper.

The usual method is to give the number of years it takes light to reach our system from them, or, as it is called, their distances are expressed in "light years." Light passes through space with the velocity of about 185,000 miles each second of time. The light of the sun is about eight minutes in coming to us. It requires nearly four hours for the light of the sun to reach Neptune. But it takes about seven years for the light to reach us from the nearest fixed star visible in this latitude, namely, the star known as "61 Cygni," in the constellation of Cygnus, the Swan. The light of the great Sirius, sometimes called from its superlative brightness the "King of the Suns," is about fifteen years in coming, while that of the North Star is fifty.

If the sun were represented by a globe two feet in diameter, the earth on the same scale would be a ball as large as a pea, about 220 feet distant. Jupiter would be the size of an orange one-third of a mile, with Neptune the size of a boy's marble one and one-fourth miles distant. On this scale a circle two and a half miles in diameter would include all the members of our solar system; but on this scale the nearest fixed stars would be nearly as distant as is our moon.

The sizes of the fixed stars are measured by their brightness. The actual disks of the planets are seen, but no telescope has been constructed which shows the disk of a star. What we do see is the beam of light, which, penetrating space, comes to our eyes after its long flight, it may be of centuries. We also know that on approaching a star its brightness would be increased and diminished if we went farther away. Now suppose that retaining your consciousness, you could go out, far beyond the confines of our solar system, to a point one thousand times as far beyond Neptune as Neptune is from the sun. But first consider the fact that when you arrived at Neptune you would receive only about one one-thousandth as much light and heat from the sun as we receive on earth. At that distance the sun would appear only a trifle larger than the planet Venus sometimes appears to us. It follows that, by increasing that distance one thousandfold, we should dwarf the sun to the apparent size of a small star. Consequently we should receive little light from him; but even at that great distance we should not have approached near enough to the thousands of suns in the direction we were going to receive from them any appreciable increase of light, and consequently we should be in a zone of perpetual darkness, unrelieved by any light except that which we know as starlight.

When you look up at night and view the "countless hosts of Heaven" which stud the blue vault above you, consider that you are looking through that vast zone of endless night—that void of densest blackness, cold and silent forever. No human stranded on an island in the midst of a broad and unnavigable ocean would be more utterly alone than is our solar system. But is it a void? Is any part of the domain of the Great Creator, so unspeakably immense as this space between us and the stars, a waste?

The question of the habitability of "other worlds than ours" has been for generations a fruitful theme of speculation. The weak point in such discussions seems to me to be in the assumption that if any other planet were inhabited, it must of necessity be with beings not materially unlike ourselves. I cannot thus limit the attributes of the Great Creator. The vast variety in all known forms of life on our planet ought, it seems to me, to be taken as a hint, at least, that He is able to call more than one form of "human" into being. Indeed, it does not require any great stretch of the imagination to conceive of intelligent beings, quite unlike ourselves in form and material, but equipped with senses so keen that our senses of hearing, and sight, and touch were dull in comparison. It is the spirit and not the material that thinks, and reasons and knows; and spirit takes no cognizance of heat and cold, light or darkness.

Observations have already furnished evidence that a dark sun is a member of our system. The light and heat of our sun are vitally necessary to existence as we know it. But were it wholly dark and cold, its attractive force would not be affected, and all the planets, themselves also dark and cold, would continue to perform their revolutions, as they have for ages past. May it not be possible, then, that outside of our system, and between us and the area filled with the visible stars, there may exist dark suns surrounded by families of dark planets, but peopled by beings as intelligent, as advanced, as happy, as well informed in regard to His works and His attributes as we are?

We call our moon dead and lifeless. The planet Mars has, we know, progressed far in the same direction. From analogy, we believe that no life, as we know it, could exist on the asteroids, and probably not on the moons of other planets. Have we the assurance to claim that all these untold millions of suns were created after our system had a being, and were created for no other purpose than to interest the inhabitants of this comparatively insignificant speck which we call the earth? For myself, I cannot doubt that systems came into being as ours did, and passed through the several stages of planetary life, reaching the stage of darkness and refrigeration, untold ages before our system passed the nebulous period.

Another consideration in connection with the question of varieties of sentient life may be named: all the life on the earth, animal and vegetable, is subject to change, depending upon a change in the conditions by which it is surrounded. Plants and animals increase in vigor and mental characteristics, or decrease in the same qualities when removed to locations more or less favorable to their development. Two children born of the same parents in the temperate zone remove, one to the tropics, the other to the frigid zone. After a few generations, the descendants of these children will be quite unlike. In like manner must mankind change as in the process of the ages the surroundings change.

But the changes wrought by natural causes take place very slowly. No one would think of questioning the statement that this earth is continually growing colder. The length of time is approximately known when this earth, having parted with a portion of its heat, when the waters of the oceans have been partially absorbed, will be unable to support life in the manner familiar to us. But while the earth, during long ages, is changing, life will also be changing to conform to the altered conditions. And this process is so gradual that during the period covered by authentic history slight evidence of such change can be found.

Scientists are agreed that life, as we know it, does not exist on our moon. Was it ever otherwise? From analogy I cannot doubt that the moon was once inhabited and may be so still. I take it for granted that no one will question the truthfulness of the adage that "like causes produce like effects." Growth on the surface of the earth is caused by heat, light, moisture and a proper soil. Given these conditions, and life must exist. If you could find some island of the sea, hitherto undiscovered, possessing these requisites, you would know in advance that there you would find life also. Now, according to the doctrine of the nebular hypothesis, substantially accepted by scientists the world over, our sun and every member of his planetary family were originally in one mass.

If one of our good housekeepers should take a quantity of flour and other proper ingredients, make the whole into one mass of dough, and from that mass mould loaves of different sizes, leaving the larger quantity as a final loaf, it would roughly illustrate the several members of our solar system in one particular. The last and largest loaf would represent the sun; the smaller, the several planets. The small loaves would require less time than the large in cooking, but in their ingredients they would be substantially alike. From the original mass of matter now forming our solar system came first Neptune, then Uranus, followed by Saturn, Jupiter, Mars, the earth, Venus and Mercury, with the remaining and much the largest mass, the sun. Some of these newly-born planets, in turn, threw off the material now seen in their respective moons. But accepting the difference caused by the operations of nature upon masses of different sizes, they must be substantially alike; and long years after the acceptance of the doctrine of the nebular hypothesis, the spectroscope comes in to corroborate it by showing that not only in our solar system, but in the sidereal universe as well, substantially the same elements exist. The sun, as well as the earth, has its salt, iron, hydrogen, magnesium, copper, zinc, nickel and many other elements. This fact is of great importance in considering the question of the habitability of "other worlds than ours."

The moon is our very nearest neighbor. The next nearest, Venus, is more than one hundred times as distant. How much do our people know about the moon? For ages it has been the object of a great amount of superstition and error. It was held to possess evil influences over mankind. The word "lunatics" comes, I believe, from the word luna, the moon. For many years it was supposed to rule the weather. So powerful and widespread was this delusion that the celebrated astronomer Herschel made continuous observations for years to detect, if possible, the basis of the claim. But notwithstanding the fact that his conclusions were positive that it had no influence upon the weather, we have some still who hold to the fallacy. In the meantime, the really important work of studying its physical geography by the scholars in our common schools has been wholly neglected. Our children study the geography of the earth, with manifest advantage. They can name the states, tell their location, boundaries, etc. Suppose from some elevation they could survey the whole hemisphere, trace the courses of the rivers, mountain chains, see the great lakes and other features. Would it not be permanently valuable, as well as interesting? Now the surface of the moon is covered with objects of great interest. There are to be seen chains of mountains, isolated peaks, areas believed to have been the beds of former oceans, volcanic craters ranging in size from those which seem but a speck to those one hundred miles in diameter. In the past, the volcanic activity on the moon must have been on a scale to which our earth furnishes no parallel.

Although the moon is now apparently cold and lifeless, it does not follow that nothing more can be learned of its past and present history. It is an attribute of weak human nature, perhaps, to consider that whatever is foreign to or unknown by themselves cannot be worthy of profound consideration. Because the surface of the moon is quite unlike that of the earth, because no evidence has been detected that she possesses an atmosphere or water, because such observations as have been made in the past do not show that changes have certainly taken place upon its surface, the conclusion seems to have been reached that it is not worth while to study it systematically, with proper instruments and under favorable conditions. I think this is a mistake, and, despairing of any movement of a public character to bring about so desirable a consummation, I hope that some time and somewhere some man of large means will endow an institution for this express purpose. Some day it may be told that evidence is in hand that the body now given over to superstition and juvenile entertainment is in reality the abode of beings superior to those who arrogate to themselves the title of "Lords of Creation."

From the nearer let us pass at a bound to the farthest known bodies. Point the telescope now mounted on Mt. Hamilton in one direction and observe the most distant star which its thirty six inch glass will pick up. Then turn it in the opposite direction, and do the same. How far apart are the two bodies thus seen? No one can tell, but they may be so distant that it requires millions of years for the light of one to pass to the other. And remember that the whole sphere outlined by these stars is studded with suns the number of which no student of astronomy has as yet been bold enough to estimate. That they number hundreds of millions is within the range of probability. And if so many suns, how many planets may there be? The mind shrinks from the task of attempting an answer. Our own system, with its comparatively small sun, numbers, as far as is now known, nearly four hundred. Suns of much greater magnitude may be the centers of planetary families numbering thousands.

Go down to the sea shore, and picking up a grain of sand, ask yourself what proportion it bears to all the sands on the shores of all the oceans on earth. The problem is as easy to answer as that of the proportion which this world bears to the habitable and inhabited worlds within the visible universe of the Great Creator. At first bewildering in the immensity and glory of the conception, in time it becomes a source of inexpressible satisfaction and reverence.

Thousands of years ago the Chaldean shepherds saw the stars as they rose over their eastern plains. Among them they saw the planet Mars, as clearly as they saw the moon. But by the unaided vision little could be positively known of any of the heavenly bodies. When in the course of time instrumental observation became possible, all were subjected to scrutiny by the keenest observers in the astronomical world. The markings on the moon, however, were much more plainly seen than on Mars. A glass which would show satisfactory details at the distance of 240,000 miles might not do so on a planet never less than about 35,000,000 miles. But the question of the habitability of either was equally in doubt and has remained so until this year, and to many remains so still.

The planet Mars has, however, been a favorite object for study by many astronomers. Seventeen years ago, a keen eyed Italian astronomer published an account of certain markings which he had seen. These markings were perfectly straight lines, running for a thousand miles, more or less, in various directions. He gave them a name which in English was translated "canals." Other astronomers with much larger telescopes could not see them and refused to believe the published accounts. But after a lapse of nine years, others did see them, and not only saw them, but found the planet partially covered with them like a network. They were estimated to be from twenty miles wide to several times that width.

The idea of a canal or straight waterway thirty or forty miles wide and a thousand miles long was preposterous. Fortunately, however, we have scientific enthusiasts who are not to be deterred from the attempt to solve difficult problems. Armed with the best instruments made by our most advanced mechanics, mounted in an observatory located in the high and dry region of Arizona, Mr. Lowell and his staff set down to pursue their investigations with sublime patience and courage. Carefully prepared maps of all the markings were made, and all the phenomena observed and studied. The conclusion substantially arrived at by them was that these markings were not water but areas of vegetation. In short that the entire system of the so-called canals was one vast and comprehensive system of irrigation.

I will not say that an absolute conclusion has been reached, but it is, I think, safe to say that at this moment astronomers are in possession of evidence of the most pronounced character that Mars has been inhabited; and if it has been, why not now? It is a matter for national pride that a young American should be the first man to make the announcement that the markings seen for years by keen visioned observers, in many lands, are areas of vegetation, which develop as our crops do in the spring and disappear, as also they do, in the fall, made possible only by the stupendous system of irrigation covering a territory larger than this entire country.

I want to call your attention to one consideration which seems to me important. The water ways, in whatever form, which form this network on Mars, in many cases run in a straight line for a thousand miles. The engineering ability to accomplish this is second to nothing ever done on this earth. Now by the unaided vision no human being could run an absolutely straight line for hundreds of miles, especially when on a curved surface like that of a planet. Only by the aid of instruments of precision as reliable as those used by our engineers could this work be accomplished. And if they have telescopes at all, as their works prove they must have, why not instruments large enough to look at this earth in detail, as our astronomers are looking at them?

Untold ages ago, Mars was in a condition analogous to the condition of this earth now. With the passing of the time, have not their people been making progress in all the arts known to them? And quite possibly some thousands of years ago they were watching this planet through superior instruments, speculating perhaps among themselves whether their nearest neighbor, so shrouded in clouds and vapors, could possibly be the abode of intelligent beings. We may imagine that they, living in a climate uniformly mild and pleasant, free from storms and disastrous gales, might have concluded that their "bigger brother" world was a totally unfit place for habitation; or if inhabited at all, probably by "monsters of the briny deep," or organisms far below themselves in the scale of being. Perhaps in that remote period they exhausted their resources in trying to signal the inhabitants of earth, in case there were any such, and discouraged at the lack of any response, came to the conclusion that it was wise to let so unpromising a subject severely alone.

[NATURE.]

LORD KELVIN ON THE AGE OF THE EARTH.

PROF. PERRY and I had not to wait long after the publication of his article "On the Age of the Earth" (Nature, January 3, 1895, pp. 224-227) to learn that there was no ground for the assumption of greater conductivity of rock at higher temperatures, on which his effort to find that the consolidation of the earth took place far earlier than 400,000,000 years ago, is chiefly founded. In a letter of date January 13, most courteously written to me by Dr. Robert Weber in consequence of his having seen by my letter to Prof. Perry, of December 13, that we were anxious to find how far his experimental results regarding differences of thermal conductivity and specific heat at different temperatures could be accepted as trustworthy, he tells me that he had made farther experiments on an improved plan, and that on the whole his investigations do not seem to prove augmentation of conductivity with temperature; and he kindly gives me, with permission to communicate to Nature, the following results, hitherto unpublished, of experiments which he made in the years 1885 and 1886 on the thermal conductivities (k) and specific heats (c) of five rocks.

	Density.	
Basalt............	3·0144	c = 0·1763 + 0·000296t [between 0° and 60°]
		c = 0·1946 + 0·000575 (t — 60) [between 60° and 110°]
		k = 0·00317 { 1+0·00001t }
Marble............	2·7036	c = 0·20279 + 0·000466.t
		k=0 00540 { 1—0·000005.t }
Rock salt.........	2·161	c = 0·2146 + 0·00017t
		k = 0·0137 { 1 —0·0044t }
Anhydrite of Jura	2·892	c = 0·1802 + 0·0003.t
		k = 0·0123 { 1 — 0·0024.t }
Quartz	2·638	c = 0·1754 + 0·0004.t
		k = 0·01576 { 1—0·0019.t }

These results show practically no change of thermal conductivity with temperature for basalt and marble. For rock salt, anhydrite of Jura, and quartz, they show diminutions of thermal conductivity amounting per 100° C. to 44 per cent., 24 per cent., and 19 per cent. respectively. They contrast curiously with the 75 per cent. augmentation of thermal conductivity per 100° C. (Nature, January 3, p. 226), used by Prof. Perry in his estimate of the age of the earth, and they form a practical comment on his statement (Nature, January 3, p. 226): "From the analogies with electric conduction, one would say, without any experimenting, that as a metal diminishes in conductivity with increase of temperature, so a salt, a mixture of salts, a rock, may be expected to increase in conductivity with increase of temperature."

Since the beginning of January I have myself been endeavoring to find by experiment the proportionate differences of thermal conductivity of rocks at different temperatures; and before the end of January I had made some preliminary experiments on slate and sandstone, from which I was able to tell Prof. Perry that the thermal conductivity of each of these two rocks is probably less at higher temperatures than at lower. Since that time I have been arranging for experiments on granite, in which as rapid progress as I would have liked has been impossible for many reasons, including the necessity of standardizing a Kew certificated thermometer of 1886, now for the first time being compared with an air thermometer in my laboratory. Unless its differences from the air thermometer are much larger than can be expected from what we know of the behavior of mercury in glass thermometers generally, it is already almost proved that the thermal conductivity of granite is less between 150° C. and 250° than between 50° and 150°.

As to specific heats there can be little doubt but that they increase with temperature up to the melting point of rock, but the rate of augmentation assumed by Prof. Perry is about five times as much as that determined up to 1,200° by the experiments of Rucker and Roberts-Austen (Phil. Mag., 1891, second half year, p. 353) for basalt, and of Carl Barus (Phil. Mag., 1893, first half year, pp. 301-303) for diabase; these being apparently the only experiments hitherto made on specific heats of rock at temperatures beyond the range of the mercury-in-glass thermometer.

Taking the primitive temperature as 4,000° C. and the thermal conductivity and the specific heat at this temperature respectively 30 times and 14½ times their values at the surface, and throwing in a factor 3 for threefold density at the greater depths (though the average density of the whole earth is scarcely double that of the upper crust), Perry takes the product of three factors 30 × 14½ × 3 and so finds in round numbers 1,300 times my estimate as his corrected estimate of the age of the earth!! (Nature, January 3, p. 227.)

But even if the ratios of thermal conductivities and of specific heats at the higher and lower temperatures were as assumed, Prof. Perry's product of the two corresponding factors vastly overestimates the age. Of this I thought I had given a sufficient warning when I wrote to him (December 13), "But your solution on the supposition of an upper stratum of constant thickness, having smaller conductivity and smaller thermal capacity than the strata below it, is very far from being applicable to the true case in which the qualities depend on the temperature." (Nature, January 3, p. 227.) It is obvious that the supposed higher thermal conductivity and the higher specific heat, if beginning suddenly at a short distance below the surface, and continuing constant to the great depth, would greatly prolong the time of cooling to the same surface gradient, beyond what it would be with these qualities increasing continuously with temperature. For the simple case of conductivity assumed to increase in the same proportion as specific heat, Prof. Perry has himself since given in a later communication (Nature, February 7, pp. 341-342) the necessary correction of his previous mathematics; and in an example of his own choosing (50 per cent. augmentation of each quality per 100° elevation of temperature), he now finds 121 times my estimate for the age of the earth, instead of 441 times as by the formula which he used in his [illegible]ticle.

[illegible] ratio of thermal conductivity to specific heat per unit bulk varies with the temperature, the problem of secular cooling presents mathematical difficulties, which, so far as I know, have not been hitherto attacked; but I find it quite amenable to analytical treatment, and I hope before long to be able to offer a paper to the Royal Society of Edinburgh on the subject, as an appendix to my original paper "On the Secular Cooling of the Earth," published in its Transactions (1862). I have already worked out numerically two cases, in one of which both conductivity and specific heat increase with temperature, and in the other the specific heat increases with the temperature but the conductivity is constant. The first of these is at present only interesting as a mathematical exercise because, according to present knowledge, it is more probable that the thermal conductivity decreases than increases with increasing temperature. To the results of the second I shall refer later as substantially helping us toward a revised estimate of the time which has elapsed since the consolidation of the earth.

Twelve years ago, in a laboratory established by Mr. Clarence King in connection with the United States Geological Survey, a very important series of experimental researches on the physical properties of rocks at high temperatures was commenced by Dr. Carl Barus for the purpose of supplying trustworthy data for geological theory. Mr. Clarence King, in an article "On the Age of the Earth," published in the American Journal of Science (vol. xlv, January, 1893), used data thus supplied, to estimate the age of the earth more definitely than was possible for me in 1862 with the very meager information then available as to specific heats, thermal conductivities, and temperatures of fusion. I had taken 7,000° F. (3,871° C.) as a high estimate of the temperature of melting rock. Even then I might have taken something between 1,000° C. and 2,000° C. as more probable, but I was most anxious not to underestimate the age of the earth, and so I founded my primary calculation on the 7,000° F. for the temperature of melting rock. Now we know from the work of Carl Barus (Phil. Mag., 1893, first half year, pp. 186, 187, 301-305) that diabase, a typical basalt of very primitive character, melts between 1,100° C. and 1,170° and is thoroughly liquid at 1,200°. The correction from 3,871° C. to 1,200° or 1/3·22 of that value, for the temperature of solidification, would, with no other change of assumptions, reduce my estimate of 100,000,000 to $1/(3·22)^2$ of its amount or a little less than 10,000,000 years; but the effect of pressure on the temperature of solidification must also be taken into account, and Mr. Clarence King, after a careful scrutiny of all the data given to him for this purpose by Dr. Barus, concludes that without farther experimental data "we have no warrant for extending the earth's age beyond 24,000,000 of years."

By the solution of the conductivity problem to which I have referred above, with specific heat increasing up to the melting point, as found by Rucker and Roberts-Austen and by Barus, but with the conductivity assumed constant, and by taking into account the augmentation of melting temperature with pressure in a somewhat more complete manner than that adopted by Mr. Clarence King, I am not led to differ much from his estimate of 24,000,000 years. But, until we know something more than we know at present as to the probable diminution, or still conceivably possible augmentation, of thermal conductivity with increasing temperature, it would be quite uninteresting to publish any closer estimate.

In the latter part of Mr. Clarence King's paper on the "Age of the Earth," the estimates of the age of the sun's heat by Helmholtz, Newcomb, and myself, are carefully considered, and the following sentences with which the paper is brought to a conclusion will, I am sure, be interesting to readers of Nature: "From this point of view the conclusions of the earlier part of this paper become of interest. The earth's age, about twenty-four millions of years, accords with the fifteen or twenty millions found for the sun.

"In so far as future investigation shall prove a secular augmentation of the sun's emission from early to present time in conformity with Lane's law, his age may be lengthened, and further study of terrestrial conductivity will probably extend that of the earth.

"Yet the concordance of results between the ages of sun and earth certainly strengthens the physical case and throws the burden of proof upon those who hold to the vaguely vast age, derived from sedimentary geology."

KELVIN.

[Continued from SUPPLEMENT, No. 1005, p. 16064.]

PEKING.*

By THOMAS CHILD.

TURNING round and looking south toward the Chinese city, right under us is a great crowd of carriages and people, on what is known to foreigners as the "beggar's bridge," from the great number of beggars that swarm here; the queen of the beggars holds her state somewhere in this locality. In the distance the Temple of Heaven rears its triple roof above the dense mass of shops and houses; it is the only tall building in this city.

Continuing west, we pass the ancient Portuguese cathedral, right under the wall. It was built by the Jesuits in 1661, by permission of the Emperor. On the return to Peking of the Roman missionaries—after having been driven out of the empire—they found the cathedral just as it had been left one hundred and twenty years before, in possession of a numerous colony of pigeons, and the accumulation of their manure sold for as much money as paid for the cleaning and repairs of the place.

The next gate close by is one that a live emperor must not pass through; it is the "dead gate," and criminals on their way to execution pass out of it. There are only certain gates that a corpse can be allowed to pass through. When the Eastern Empress died—the late Emperor's stepmother—her body was carried out of one gate, while the Enperor following it went out at another, because a live emperor could not pass through that gate. No dead body is allowed to be brought into the city, neither can one inside be allowed to cross the city in front of the palace.

Returning to the gates we entered the city by, and coming down from the wall, we pass along the small streets and lanes to the left of the gate, and arrive at the Peking Observatory, the oldest in the world, and, perhaps, the most dilapidated. Like nearly all things in China, its time has passed, and to render it of any use, it would not only require a new set of instruments, but new men with modern ideas also. Anyone expecting to find highly finished, shining brass instruments, such as are found in western observatories, will be disappointed; were the instruments not made of imperishable material, they would have disappeared centuries ago, having been made in 1275, when the observatory was founded by the Mongol Emperor Kublai Khan.

Two of these instruments have been out in the open, exposed to all weathers ever since. The front gate is not a very imposing structure, but it carries the marks of age. I have never seen it used, a gate round one end serving the purpose for entering the courtyard, where we see, in front of us, the principal building of the observatory, with the doors sealed up, in no better condition than the front gate. In front of these houses are the two instruments made by the Mongol Emperor, an armillary sphere, supported by four dragons. The Chinese say, and believe, that there were originally five, but one flew away, so the other four have been chained up by the forearm. By the side of this is an astrolabe of the same date; both instruments are beautiful specimens of the moulder's art, and are among the finest pieces of bronze extant.

Notwithstanding their exposure, they are just as sharp and smooth as when turned out of the hands of the workmen six hundred years ago. This observatory is immediately under the east wall of the city, and turning round to face the wall, we have the square terrace that we passed on the city wall right before us. It is 70 feet high from the ground and has steps running round two sides to ascend to the top, where are placed eight instruments of later date, one being a bronze celestial globe, 7 feet 6 inches in diameter, with the constellations standing out in relief on its surface. All these newer instruments were made by the Jesuits about 150 years ago. Taken as a whole, I should think this is the finest collection of bronze in the world.

Although so many years have elapsed since the Mongol conqueror ordered astronomical instruments to be made in Peking, and they have withstood the frosts and heats of so many decades without the slightest injury, could we see them after the lapse of a similar period in the future, we should probably find them in the same perfect condition—like the nation time changes but little.

In the existence of such a people as the Chinese, 600 years are as nothing; dynasties come and pass away. Other nations are ever changing, but this mighty people remain, with scarcely any difference, what they were hundreds of years ago, in spite of famines, floods, wars and civil contentions, destructive enough to human life and property to exterminate many a smaller country. In the late Tai ping rebellion, during the 14 years it lasted, 20,000,000 human beings are said to have perished, but the people are like the rising tide, irrepressible, and, in spite of every effort to keep them back, they are advancing and overflowing into other countries, and must do so.

Peking, as a city with its monuments and temples, bears indisputable evidence of old age. During many reigns, very little money has been spent in the repairs of the useful parts of the city; the Observatory, with such gems of workmanship, must have been in a chronic state of decay for years. The instruments do not show it, but the bricks and mortar all over the city show the wear and tear of the ages. The northwest wind that blows with such force, bringing with it clouds of sand, forms a perfect and destructive sandblast, which cuts away the center of the bricks that are exposed to its force. In all the old brickwork facing the northwest, the middle of the face of the bricks is scooped out, while the hard skin remains with the mortar like a frame round it—this is all the effect of the dust.

Probably any other nation would have its Observatory under cover as much as possible—this is another proof of the Chinese doing things contrary to European notions; even the outside walls are in a tumbledown state, leaving the yard open to the street, and children avail themselves of it for a playground, climbing and tumbling about the instruments, but, fortunately, doing more harm to their shins and clothes than to the bronze. Trees grow in various parts of the yard, between the joints of the brickwork and through the cracks in the stones, displacing with their roots the level of the instruments. Before I could photograph one of them, I had to wait several months until a large tree that had been blown down and covered it up had been stolen little by little. A guard of Manchu soldiers are constantly on duty, but their principal business seems to be extracting the money from visitors.

The buildings on the north side seem to be the place where work was done, as they contain large and heavy tables, with a thick carpet of dust on them. The windows extend along the south side of the building; they are like those of ordinary Chinese houses, made with a wooden framework, which is pasted over on the inside with paper. This lets in light, and keeps out cold; but the view from the inside is somewhat restricted. As all the paper that was on these windows had been eaten off by wasps, the thick carpet of dust on the floors and furniture is easily accounted for. The roof is covered with yellow porcelain tiles, the imperial color. All the palace buildings are so roofed; but this, like the rest of the place, is much out of repair.

Near to this place is the Examination hall, in the yard of which are 15,000 small cells, 3 feet wide by 4 feet deep, open at the front, and containing only a piece of board for a seat and another piece for a table. To protect himself from the weather, and make the place more private, the candidate buys a piece of mat, and hangs it up in front as a blind. In each of these cells one candidate is shut up for two nights and one day, and not allowed to leave under any pretense. The food is cooked and supplied by men employed by the government, one coolie begin allowed to ten men. The food is white rice only, any other luxury being provided by the students themselves. During the day of entering, the candidates flock in, and are searched by the numerous mandarins in attendance. No book or writing material is allowed inside: their places are allotted, and the gates closed. Then a committee of

* A recent lecture before the Society of Arts, London. From the Journal of the Society.

mandarins determine what the subject to be written upon is to be. This is handed to the wood block engraver, it is cut, printed, and handed round to the different men, each question being the same. The candidate has a plain book handed to him with his name bound up in the cover, so that he is compelled to use the book supplied by the government. The subjects are quotations from the Chinese classics, a character or two only being given, the student having to take up the theme if he can. Candidates from all parts of the empire flock to Peking, and at the great examination as many as 15,000 enter. Many die, and their bodies are thrust out through a hole in the wall provided for that purpose, where there are benevolent persons waiting to take the corpse and bury it at their own expense. The Chinese say—here superstition comes in again—that ghosts wander about at night up and down the alleys of cells, lifting the curtains and peeping into the little rooms; when the unlucky person is found against whom the ghosts have a spite, they rush in and strangle him. Common sense says it is a case of suicide. The graduate finding he cannot do the paper, and not having the courage to return to his village a failure, ends his life. When we think that out of this great number there can only be about 200 take the M.A. degree, we see how slight a chance there is for many. Yet all the examination halls throughout the land are perpetually crowded, and if we consider the amount of mental toil which the mere entrance to any of these examinations involves, we get a very vivid conception of the intellectual industry of the Chinese. In what land but China would it be possible to find examples of a grandfather, son, and grandson all competing in the same examination for the same degree? Many memorials have appeared in the Peking Gazette relating to the aged candidates. At the provincial examinations in one of the provinces 35 of the competitors were over 80 and 18 over 90 years of age! Could any country in the world afford a spectacle like this?

Continuing our journey westward among the lanes, we find fine buildings and hovels all grouped together, the prince having for his neighbor the small tradesman, and each equally proud, the trader considering himself as good as the prince. To be in business is no disgrace, on the contrary it is considered an honor, and a man who deals in matches thinks as much of his position as a banker. They are both serving the commonwealth, and both useful in their own way. I once overtook a man in the country, and he told me he had seen our "firewheel boats" at Tientsin, where he had been a merchant. I thought I had got hold of a big swell, and inquired where his offices were. He informed me he had no offices. He dealt in needles. He saw nothing to laugh at in the matter; it was an honorable occupation, and something to be proud of. In one of these narrow lanes we find the Tsung li Yamen, the Chinese Foreign Office. Inside the gate is a portal on which are four characters, meaning "Prosperity at home and abroad." The buildings inside are of the usual Chinese style of one story, with paper windows, the principal rooms facing south, all with brick floors. This is one reason why the Chinese have such thick soles to their boots. A Chinese room, to our western ideas, lacks comfort, as there are no chimneys in the houses; the fires are made in pots in the middle of the room, and though smokeless coal is used, there is a certain amount of fumes that are not at all pleasant. The fire is not so much for heating the room as for making water hot for tea, and they depend on their clothes for warmth in the winter. At this place there is a college, under foreign professors, for teaching the Chinese languages and science, the students being fed and paid a monthly salary to come and study.

Passing on, we go through the fore court of a prince, and pass the front door, not of his house, but of his courtyard, the houses are out of sight; they are a series of one story rooms, with paper windows and brick floors. The front hall that we are passing is a very large building, with stone lions on either side of the steps; it is the regular custom to have bronze or stone lions outside these large residences. The gardens inside are laid out very beautifully; nature is imitated in a miniature way with rock, water, and trees. If a Chinaman has only a few feet for a back yard, he will try and introduce some rocks and water. We arrive at length on one of the big streets, with its fine shops, many with carved and gilded fronts. The shops, so different from our idea of them, are all open in the front to the street, with no windows in which to exhibit their wares to tempt the money out of people's pockets. It is as well to know what is required before going into them. The shopkeepers are a hard working class, up with the sun, and the shops are swept ready for customers almost before it is well light. There is no Thursday closing, or Sunday either, and so far as I know, no grumbling; about the only holiday is New Year's Day, then all shops are shut. The streets, though wide, are much cumbered by booths and stalls, some of them quite substantial structures, others taken down at night; here gathered under an awning is a large audience seated on benches listening to a story teller, on the outside is a man with a huge teapot well wrapped up in cotton wool, as they do not possess any flannel, to keep the tea warm until he can sell it out at one cash a cup. Another man has a fire with an iron girdle on the top, on which he is cooking, in oil, little tasty smelling lots of mutton and onions. I may state I never saw dog's flesh offered for sale, or anything in the way of meat worse than a donkey. I have seen very poor people dragging away dogs, and have been told they would eat them; but that was because they could not get anything better, not from choice. But this is a very long subject, and I had better pass on.

Among other curious things we are sure to see is a bier arranged out on the street. Funerals are great institutions in Peking; in fact, these and weddings seem to be the only jolly times the poor folks have; they are both made a time of feasting, and, to us foreigners, one seems about as gay as the other. This bier is waiting for the coffin, the funeral taking place the day after the bier is erected in the street, when the coffin is placed on it; the whole structure is borne on the shoulders of sixty-four men, and carried to the grave; it is very heavy, and must weigh much more than a ton. Fancy erecting a structure like this in the middle of the Strand! The traffic has to go where it can. Beggars we are certain to see; I once photographed a group of them and gave them each one shilling; they grumbled at the little money, and accused me of wasting their time. As distances are great, it is as well to take a cab, of which we see many hundreds in the streets; we foreigners call them carts. It is just a box on wheels, without springs, covered on the top with a wooden framework, over which is stretched blue shirting; the wheels are very heavy, the axles, of hard wood three inches in diameter, stick out beyond the wheels about six inches. The driver sits on one side of the shafts, but, before he starts, he takes a brush out of a little bottle that hangs by the side, and oils the wheels; under his seat, under the cart, is a basket and a little tub, the one is a nose bag and the other is a tub to supply the animal with water. When the horse is feeding it is used to stand the basket on. The proper way is to get inside these carts and sit tailor fashion, but the rough roads and lack of springs cause us to alter our minds and sit like the driver, on the other side of the shafts; this is by no means comme il faut, and never adopted by any respectable Chinaman, but we think it better to withstand custom for the sake of moderate comfort. These vehicles have a blind that can be let down over the front, but it in no way keeps out the cold or dust. As Chinese etiquette demands that one gentleman shall not pass another if he knows him without dismounting if riding, or getting out of the cart if driving, and making a formal bow and greeting, the journey has many breaks and is necessarily slow. To get out of this greeting ceremony the blind is let down in the cart and the passengers pretend they are not there, and get on their journey as fast as they can.

By this time we have arrived at Legation Street. It runs parallel and near to the south wall of the city. The whole of the legations and the inspectorate of Chinese maritime customs are within an area of half a mile. They are nearly all situated in parks surrounded by high walls. There is nothing to be seen from the streets but the gates and walls, except the British legation, which has built several two storied houses; and the tops of these can be seen from some distance. The Russian legation is the oldest, having existed in Peking for over a hundred years. Near the legations are the principal government offices. Five of the six boards are on the east of the Imperial city, and one, the board of punishment, on the west. There is nothing particular to call attention to in these buildings, they are built in the usual Chinese style of one story and a large courtyard in front, with perhaps more than the usual quantity of dirt and dilapidation.

The board of punishment, called the "hsing pu," on the west, is the best known; it is the state prison, and cannot be visited by foreigners unless they stay, and I have never heard any one express a wish to do so. The late Sir Harry Parkes describes the horror he felt when he passed within its chained gate. Like the examination hall, there is a hole in the northwest corner of the wall through which the bodies of the unfortunates done to death are thrust. I do not think prisoners are actually executed within the walls; they are only tortured to death. There is a public execution ground outside in the Chinese city.

Following the canal by the front of the British legation brings us to the corner of the wall of the Imperial city. It is about six feet thick and twenty five feet high, and seven miles round; the top is roofed with yellow porcelain tiles. This is a characteristic of Peking. All the public buildings are covered with these glazed tiles, every dynasty having its own color, some green, some yellow. The present dynasty, which is the "ch'ing" or "pure," has adopted yellow. All the palace buildings are covered with tiles of this color. There is a moat inside the walls, crossed in various places by stone bridges. The city is entered by three gates, one in the east wall, one in the north wall, and one in the west wall. I have already spoken of another, the "great pure gate" in the south; but as that is not for common people, I do not notice it again. These gates are inside a large hall; they are not closed at night. As the Emperor transacts all state business very early in the morning, mandarins are constantly coming and going, and when lazy people get up to go to business about nine in the morning, crowds of these courtiers and their suites are to be seen hastening home, after their early audience with the Emperor. About half a mile inside these gates are the gates of the Forbidden city, something like the large gates in the big wall of the Tartar city. As that is very much forbidden ground, we pass on, and in the center of the city—still forbidden—is a hill about 300 feet high, said to be composed entirely of coal, for use in case of a siege. There are five pavilions on the top, that were built during the Ming dynasty. It was here that the last Emperor of the Ming dynasty, finding all was lost, hanged himself—the Chinese say on a crab apple tree—and the tree can be seen to this day in chains. I inquired if it was not foolish to put a tree in chains. They said, "No: the tree has sinned, and must be punished."

On the south of this coal hill is a broad moat that encircles the Forbidden city, and on the other side are the walls; they are two and a quarter miles round, guarded by numerous stations of bannermen. There are three gates into this city. No one but Chinamen that have official business and wear official hats are allowed to enter; no person, whatever his position, is allowed to drive, ride, or be carried in a chair inside this city—all dismount at the gates. According to the notions of the common folk, all here is gold and silver. They will tell you of gold and silver pillars, gold and silver roofs, gold and silver vases in which swim gold and silver fish. All this part of the city is just as it was left by the Mings in 1644. When the conquering Manchus swarmed in, they found a magnificent city and palaces all ready for them, uninjured and strong, which were apportioned among the victorious army for habitation. This army consisted not only of Manchus, but of Mongols and Chinese, and was divided into eight banners; thus they were called bannermen, and very few Chinese merchants were allowed to reside in the Tartar city. The Chinese, called "Min Jen," were obliged to live in the southern Chinese city. Partly by intermarrying among the banners of different nationalities, and, in much rarer cases, among the ordinary Chinese, the Manchu element has become almost absorbed, and the Manchu language, as a living language, has disappeared in Peking, though it is still used as the court language. The greater mass of the population strikes the observer who comes from the south as taller and stronger built, which shows the mixture of the Manchu blood. Until within the last fifty years the whole population of the Tartar city consisted of bannermen, but now there are many Chinese among them. These bannermen are the virtual army of Peking, and it costs the government £160,000 every month to keep them on starvation pay. They form the whole of the police, amounting to 12,000 men, most miserably clad. They are the firemen, and also keep the streets in repair. As a class, the bannermen are lazy and proud; as soldiers, there is the making of good men in them if they were properly trained; at present they are worse armed and trained than any soldier in China. Many are armed with bows and arrows. Skill in archery and great physical strength are deemed of more importance than any other attainments relating to war.

On the north side of the moat, not in the forbidden part, is the Temple "Ta-Hao-tien." It is used by the Emperor when any national circumstance demands prayer, such as want of rain or snow. It has three portals, one on the east, one on the south and one on the west. The Emperor enters by the southern one. They are made of wood, beautifully lacquered and painted. There are two houses with very complicated roofs, covered with yellow tiles, just inside. These would be used by the guard during the Emperor's visit.

The road runs right through the palace gardens, crossing a fine lake by a marble bridge. From here we get a peep at the inside. This is one of the most beautiful spots in the city. The lake, more than a mile long, in summer is covered with a mass of lotus, whose round leaves form a carpet of green, dotted with myriads of pink flowers as large as basins, which help to make a beautiful picture that any one could admire; the perfume from the flowers, wafted by the wind, can be smelt half across the city. In winter the lake is covered with ice as clear as crystal, on which the imperial family disport with sledges. On the banks of the lake are handsome summer houses and temples, beautiful groves and examples of the art of landscape gardening, in which the Chinese excel. The hill, which is an island, is capped by a marble dagoba. Here there is an altar to the originator of the silk manufactures and to the presiding genii of the silkworm; round it are mulberry trees. The Empress comes here annually to feed the silkworms; she thus sets an example of industry to the working women of the empire. The building to the right is a temple dating from the Mongol times. The high wall is overhung with the branches of the white pine, which only grows round Peking. It is now impossible to go on this bridge, as the Emperor Kuang-Ssu has ordered the road across it to be closed, and anyone now wishing to cross the city has to make a detour round the wall of the Imperial city.

On the southeast side of the palace is the "Tai-Miao," the Temple of Ancestors. It is the family temple of the Emperor, and more honored than any religious structure, except the Temple of Heaven. To be on the south, and also on the east of the palace, is the summit of honor.

In the street leading to the west gate is another celebrated temple, dating from the sixteenth century. It is called "Li tai-wang-Miao," dedicated to the kings and emperors of all dynasties, containing tablets inscribed with their names. It is an impressive sight, these simple tablets of men who once ruled this kingdom, standing here side by side, worshiped by their successors, that their spirits may bless the state. On our way we cannot help but notice wooden arches that span the street in various places. I think in these cases they are just for ornament, and seem to mark a locality; some of them are in the last stages of decay. The street lamps are most substantial structures; a wooden lantern, glazed with paper, standing on four legs. The illumination is not at all in proportion to the strength of the lamp. The light is obtained from a small clay saucer, with oil, in which is a small wick, and it just serves the purpose of preventing persons running into the lamp; as they are only lighted on moonlight nights, they may be credited with lighting the city.

Continuing our journey out of the north gate of the Imperial city, we come to a most substantial brick structure, 99 feet high, and about 50 feet square, with tunnels running through it in the form of a cross. This is the Drum Tower, containing a large drum, which is beaten in times of alarm, and to give the watches of the night. A little to the north of it is the Bell Tower, in which is hung one of the five bells which the Emperor Yung Lo (second emperor of the Ming dynasty) caused to be cast at the beginning of the fifteenth century. The bell weighs 120,000 lb., and is covered inside and out with 250,000 Chinese characters. This tower was built by the Emperor Ch'ien Lung of this dynasty, the bell having formerly been hung on an open scaffold.

There is a large Mohammedan population. All the sheep killed in the city are killed by Mohammedan butchers. There are also several mosques. Chinese historians say that the Emperor Ch'ien Lung built one for his favorite wife, who was a princess from a tribe of Turkestan.

In the northeast of the city is a most famous Buddhist temple, the Yung-Ho-Kung, or "Lamasary of Eternal Peace," where 1,500 Mongol and Tibetan priests study the dogmas of Buddhism, or spend their days in idleness, under the control of a Gegan or living Buddha. The rehearsal of the prayers and chants by so many men is very fine and impressive. They chant the prayers and drink porridge out of a pail. There is a wooden gilded idol of Mait re ya, the coming Buddha, 70 feet high. The priests in this temple are very rough, and though they are prepared to show visitors round and take their money, they will stand no nonsense; I mean they will not allow globe trotters to steal the little idols that line the wall in thousands. They reserve that privilege to themselves; they are most averse to photography, and several times I have been bundled out with all my kit, pretty roughly. The Mongols are of a different temperament to the Chinese; where the latter would put up with an amount of insult provided it paid, the Mongol would adopt the old English argument and punch your head. There is a Buddhist Bible in this temple, unabridged, complete in 400 volumes.

We often accuse the Chinese of doing things

tury, and, among other things, of putting on the roof of a house before they build the walls; this is a fact, and we pass a temple in which they are working on the roof before a brick is put to the walls. In building they do not trust to the walls for supporting the roof, they are used to stop up the sides; the roof is supported on posts which, in course of time, rot at the bottom and let it down.

Within a short distance is the Confucian temple, embowered in a grove of ancient cypress trees, said to be more than 1,000 years old; the building is a fine imposing structure, from 40 to 50 feet high, supported on thick teak pillars, brought from southwest China. In front is a broad and handsome terrace with balustrades in white marble; it is ascended on three sides by 17 marble steps. There are no idols in this place, simply tablets to Confucius and the other sages; the inscription is in Chinese and Manchu. All is simple and quiet here; the scene presents an impressive instance of the merited honor paid to the moral teachers of the people. Round the roof are hung handsome tablets in praise of Confucius; each Emperor presents one in token of veneration for the sage. Every inscription is different, and presents some aspect of his influence. He is called, "Of all born men the most unrivaled," "Equal with heaven and earth," and there are many such sentences in this strain. Here the Emperor or his representative worships the great sage twice a year. In front of this hall is a handsome portal in which are the celebrated stone drums; they are believed to date from the Chin dynasty, 200 years after Confucius, and to be, therefore, about 2,000 years old; as the characters were becoming illegible, the Emperor Ch'ien Lung had some new stones cut, and placed on the south side of the gateway. In front of them is the court of triennial examinations for the highest literary degree of the Chinese, "Chin Shih" (doctor of literature). A stone is here erected in commemoration of each examination, and the names and residences of all who have received this title are inscribed on them; the oldest are three still remaining of the Yuan dynasty, five centuries ago, and up to the present time the monuments are nearly complete.

Adjoining the Confucian temple is the Pi Yung Kung, or the Hall of the Classics; it is generally known as the Kuotze Chien. Besides the beautiful hall built by the Emperor Ch'ien Lung, in the center of a marble pond, there is a magnificent porcelain arch, covered with yellow tiles, and on each side of the place, in long cloisters, stand 200 upright stone monuments, engraved on both sides; which contain the complete text of the nine classics.

These are about the principal things to be seen inside the city of Peking.

I have endeavored this evening to give you a general opinion of what Peking is like. I have refrained as much as possible from entering into many details as it would be impossible, in one evening, to notice the many important places in the city. In an ancient city like Peking, with everything so strange to western ideas, all one sees naturally excites curiosity, and there is an abundance of facts connected with almost everything. I have told you only what I know to be true, or what has been related to me by the natives, and I have endeavored to verify as much as I could by photographs taken by myself, most of them by the collodion process. I am not asking you to consider them as works of art, as I have had to get many under great difficulties, and have only used them this evening to illustrate my subject, and make it easier for me to convey the ideas I wish to give you.

LICHENS.

LICHENS are familiar as brown or gray crust-like patches on rocks, old stumps, the trunks of trees, and even on the ground. Those on trees are frequently pendent, and are known as long moss or beard moss. Those on the ground frequently produce little cup-like structures bearing bright red tips. If we cut a thin section from one of the leaf-like forms and study it under a microscope, we shall find that in the central portion there will be seen a number of green, blue-green or brown-green cells (gonidia), either separated or arranged in groups. Surrounding these cells, both above and below, is an interwoven mat of long, slender, colorless cells (hyphæ). The hyphæ may be simple or branched and divided by partitions into longer or shorter segments. The greenish or bluish cells in the center are algæ that have been seized upon and enveloped by a parasitic fungus, the two forming together the composite organism known as the lichen.

The algæ which enter into the composition of lichens are all fresh water plants, living normally either in ponds, slow-moving streams, on damp walls, tree trunks, or even in moist places on the ground. This class of plants may be typified by the waving, bright green, hair-like growths so often observed in ponds, quiet streams, or in and about watering troughs. Besides these, which consist of a chain of short cells placed end to end, there are numerous others living in the same places that during their whole life consist of single, simple, more or less spherical cells. They are so very minute as to be singly invisible to the naked eye, but in masses produce a characteristic green color. One of the simple one-celled forms is well known as producing the bright green coloring of tree trunks, old fences, the sides of brick houses and brick walks, which comes out so strikingly on damp or rainy days. The kinds of algæ made use of by the fungus are usually simple celled, but the slender, chain-like forms are also sometimes seized upon. The hyphæ of the lichen fungus embrace the algal cells, and the two elements together compose a structure of definite form.

The fungus element of the lichen is the only one which produces reproductive bodies. These are single-celled bodies called spores, and may be likened to the seeds of flowering plants. It was found that when these spores germinated they were unable to develop beyond a certain stage unless they were supplied with a number of algal cells. A distinguished German investigator was able to produce in the laboratory a well-known species of lichen by combining the proper fungus and algal cells, and it is said that three species have been manufactured artificially in this way.

It would hardly be expected that such humble plants could play a very important role as a food supply for man, yet they do have an importance and value. In Arctic lands, where other kinds of vegetation are scanty or absent, there is usually an abundance of lichens. "Iceland moss" is a well-known lichen found abundantly in Iceland. It is gathered in large quantities by the natives, deprived of its bitterness by boiling in water, and then dried and reduced to powder. It is usually used with flour and milk or made into cakes, and in times of great scarcity it forms almost the only article of food. Another edible lichen is known as "rock tripe." It also inhabits Arctic countries, growing in crusty patches on rocks. It is usually boiled and eaten only when other things fail. But perhaps the most interesting of all the esculent lichens is that known as the "manna lichen," which in times of famine has served as food for both man and cattle in the arid steppes from Algeria to Tartary. It grows in layers from three to six inches thick, and over vast areas it is found in the form of small irregular lumps of grayish or white color. The "reindeer moss," so abundant in cold countries, especially in Lapland, is also a lichen and furnishes almost the entire food of the reindeer during the winter months. Lichens supply a number of valuable dyes—archil, a rich purple dye; cudbear, formerly much used by the peasants of Northern Europe to give a scarlet or purple color to woolen clothes; litmus, an indigo blue coloring matter much used in chemistry; and several more or less valuable yellow dyes are afforded by various lichens, as well as a number of red, purple or brown dyes.—F. H. Knowlton, Ph.D., in Popular Science News.

[FROM KNOWLEDGE.]

NEW ANIMALS FROM MADAGASCAR.

By R. LYDEKKER, B.A.Cantab., F.R.S.

AT a time when public attention is directed to Madagascar as the scene of an impending war, our readers will doubtless be glad to hear something of certain new discoveries which have recently thrown much additional light on the past zoological history of this most interesting and remarkable island. Probably many of them are aware that the Malagasy fauna differs most strikingly from that of the African mainland, in spite of the small extent of sea by which the two areas are separated from one another, and it is evident that although the ancestors of the majority of the animals now inhabiting Madagascar obtained an entrance by means of a former land connection with East Africa, yet the date of that connection must have been extremely remote. At the present day, Africa south of the Sahara desert is specially characterized by the numbers of species of antelopes of various genera which swarm on its open plains, as well as by giraffes, zebras, rhinoceroses, elephants, hippopotami, wart hogs, bush pigs, lions, leopards and various other large cats, baboons, man-like apes and ostriches. On the other hand, with the exception of one living species of bush pig and a fossil hippopotamus, not a single representative of any one of these groups is met with in the adjacent island; and, as has been pointed out by Mr. Wallace, it would appear quite probable that both the pig and the hippopotamus may have obtained an entrance by being carried across the channel—possibly at a time when it was somewhat less broad than at present. In place of the animals mentioned above, we find in Madagascar numbers of lemurs, all belonging to genera and species distinct from those inhabiting either Africa or India, and so numerous that they form nearly one-half of the whole mammalian population of the island.

Civet and ichneumon like carnivores, likewise pertaining to peculiar genera, are also abundant, and these seem to affiliate the fauna to Africa rather than to Asia, seeing that such animals are more numerously represented in the former than in the latter continent. Among the most remarkable of these civet like creatures is the so-called fossa (Cryptoprocta), which has a uniformly sandy coat, and may be compared in point of size to a short legged lynx, this creature differing so markedly from all its allies as to be entitled to represent a distinct subfamily by itself. It has, indeed, been considered that the fossa is closely allied to certain extinct carnivores from the lower Tertiary deposits of Southern Europe, and, although some writers are disinclined to accept the relationship, it is not improbable that the theory is well founded.

One of the most remarkable features connected with the mammalian fauna of the island is the circumstance that the family of the insectivorous order known as the Centetidæ is represented elsewhere only in the West Indies, although the generic forms inhabiting the two areas are distinct.

Another apparent indication of American affinities is afforded by the presence of iguana lizards (Iguanidæ), which are now unknown in any other part of the Old World except the Fiji and Friendly Islands. Iguanas are, however, found in a fossil state in the lower Tertiaries of Europe, and it therefore seems probable that their present anomalous geographical distribution may be explained by dispersal from a common northern center, although it has been thought to indicate a connection between Madagascar and South America.

If this be so, a similar explanation will hold good in the case of the Centetidæ, although, in spite of statements to the contrary, these have not yet been discovered in a fossil state. It will likewise serve with regard to the occurrence of an identical genus of fresh water tortoises in Madagascar and South America, and also of certain resemblances between Malagasy and Australian reptiles.

With regard to the former connection between Madagascar and the mainland, the occurrence of marine strata of Eocene age in Egypt and other parts of Northern Africa proves that at the period of their deposition the portion of the latter continent lying to the south of the Sahara was cut off from Europe and Asia by an arm of the sea, so as to form an island continent, in the same way as was South America during some part of the Tertiary epoch.

Probably, soon after this, or in the upper Eocene period, this Ethiopian island, as it may be called, of which Madagascar evidently formed a part, was temporarily connected with the northern land when it received its fauna of civets, lemurs and insectivores, which a subsequent disconnection allowed to develop without persecution from higher forms of later age. During this time Madagascar became separated, and in the upper Miocene or lower Pliocene age Southern Africa once more became connected with Europe and Asia, which (like North America) were then the home of the various large mammals mentioned above, as well as ostriches. This connection thus allowed a later and more highly organized fauna to sweep over Asia, where it found a free field to develop at the expense of creatures of a lower type.

On the other hand, the isolation of Madagascar allowed the more primitive fauna to remain there unmolested, and to attain a richness of development which was never reached elsewhere. As to the date when the ancestors of the gigantic flightless Malagasy birds known as Æpyornis obtained entrance into the island, further evidence seems necessary, as we are not at present aware that any nearly allied forms existed in the European Eocene, unless, indeed, we are to look upon Gastornis of the London Clay and corresponding strata of the Continent in that light.

The giant tortoises, whose remains are found in the superficial deposits of Madagascar, belong to a group which was widely spread over Europe in Tertiary times, and their ancestors may consequently have entered with the primitive insectivores, civets and lemurs. From Madagascar, according to the views of Mr. Wallace, the adjacent islands, which, in comparison, are exceedingly poor in mammals, received such forms of life as were capable of crossing the intervening sea; while, in their turn, they formed the stepping stones by means of which the larger island was populated by such Indian birds and insects as had been able to reach them.

At the present day, the existing lemurs of Madagascar may be compared in point of size to small or medium sized monkeys, the largest of them—the short tailed indri—not measuring much more than a yard in length. The investigations recently carried on by various intrepid explorers in the island have, however, revealed the fact that up to a very late period Madagascar was the home of a lemur vastly exceeding in size any of the existing representatives of the group, and which in this respect may be compared to the great West African baboon known as the mandril. This giant lemur (Megaladapis, as it is called by its describer, Dr. Forsyth Major) is known by the somewhat imperfect skull and lower jaw, which are about three times the dimensions of those of the indri. The interest of this animal is, however, by no means confined to its comparatively gigantic proportions, since, while its skull and teeth conform in their general structural features to those of the existing members of the group, they are specially modified in a manner altogether peculiar.

The most striking peculiarity connected with the skull is the extreme slenderness of the hinder portion containing the brain in comparison with the great elongation of the face; the latter seeming out of all proportion to the former. In this respect, indeed, the skull presents a curious resemblance to the so-called dog faced baboons of Africa; as it also does in the strongly marked ridges it bears for the attachment of powerful muscles. Such resemblances, however, it is almost needless to observe, are merely superficial, and must, by no means, be taken as indicative of any genetic relationship between the two groups; and if a young skull were forthcoming, it is probable that we should find this much less unlike ordinary lemurs.

Another peculiarity of the giant lemur is to be found in the more lateral position and wider separation of the sockets of the eyes, which are also relatively smaller than in existing forms, thus indicating that the habits of the animal were less completely nocturnal than those of the latter. The molar teeth of the upper jaw are characterized by the presence of only three tubercles on the crown, owing to the fusion of the two inner ones of the four columned molars of ordinary lemurs; a few of the smaller existing species having, however, teeth of a nearly similar type.

Although in the type skull the front teeth are wanting, the form of their sockets shows that they must have been very similar in general form to those of living lemurs. It many respects the skull shows a marked resemblance to that of the European Tertiary lemur known as Adipis, a feature of especial interest in regard to what we have said as to the origin of the Malagasy fauna from that of the Eocene period in Europe.

The remains of the giant lemur were discovered in the great marsh of Ambolisatra, and their slightly mineralized condition indicates their comparatively recent age. Indeed, there is but little doubt that the creature has been killed off within the human period, and in his history of Madagascar, published in 1658, De Flacourt writes in the following terms of an animal then inhabiting the island, which, if not actually the giant lemur, would appear to have been a closely allied form. He writes that "Trétrétrétré ou Tratratratra, c'est un animal gros comme un veau de deux ans qui a la tête ronde et une face d'homme; les pieds de devant comme un singe et les pieds de derrière aussi. Il a le poil frisoté, la queue courte et les oreilles comme celles d'un homme. Il resemble au Tanache d'escrit (sic) par Ambroise Paré. Il s'en est vu un proche l'étang de Lipomani, aux environs duquel est son repaire. C'est un animal fort solitaire, les gens du pays en ont grand peur et s'enfuient de lui comme lui aussi d'eux." With the exception of the rounded head and the size (which is doubtless exaggerated), this description accords remarkably with the giant lemur, and when the head was covered with fur it is probable that it would appear much less elongated than does the bare skull.

The giant lemur is, however, not the sole extinct member of the group recently brought to light, since the hinder part of a skull indicates another large species belonging to a new genus, but apparently allied to the existing Malagasy lemurs known as Hapalemur.

Although the extinct Malagasy hippopotamus (H. lemerlei) was named as far back as 1868, it is only recently that we have become fully acquainted with its affinities. In spite of its smaller size, it appears to have been nearly allied to the living African species. As it is somewhat difficult to believe that a hippopotamus and a bush pig could have swum a channel of the width of that separating Madagascar from the mainland, it is not improbable that in the latter part of the Tertiary period this was much narrower—perhaps not more than ten miles in width.

From the same marsh of Ambolisatra which yielded

mandarins determine what the subject to be written upon is to be. This is handed to the wood block engraver, it is cut, printed, and handed round to the different men, each question being the same. The candidate has a plain book handed to him with his name bound up in the cover, so that he is compelled to use the book supplied by the government. The subjects are quotations from the Chinese classics, a character or two only being given, the student having to take up the theme if he can. Candidates from all parts of the empire flock to Peking, and at the great examination as many as 15,000 enter. Many die, and their bodies are thrust out through a hole in the wall provided for that purpose, where there are benevolent persons waiting to take the corpse and bury it at their own expense. The Chinese say—here superstition comes in again—that ghosts wander about at night up and down the alleys of cells, lifting the curtains and peeping into the little rooms; when the unlucky person is found against whom the ghosts have a spite, they rush in and strangle him. Common sense says it is a case of suicide. The graduate finding he cannot do the paper, and not having the courage to return to his village a failure, ends his life. When we think that out of this great number there can only be about 200 take the M.A. degree, we see how slight a chance there is for many. Yet all the examination halls throughout the land are perpetually crowded, and if we consider the amount of mental toil which the mere entrance to any of these examinations involves, we get a very vivid conception of the intellectual industry of the Chinese. In what land but China would it be possible to find examples of a grandfather, son, and grandson all competing in the same examination for the same degree? Many memorials have appeared in the Peking Gazette relating to the aged candidates. At the provincial examinations in one of the provinces 35 of the competitors were over 80 and 18 over 90 years of age! Could any country in the world afford a spectacle like this?

Continuing our journey westward among the lanes, we find fine buildings and hovels all grouped together, the prince having for his neighbor the small tradesman, and each equally proud, the trader considering himself as good as the prince. To be in business is no disgrace, on the contrary it is considered an honor, and a man who deals in matches thinks as much of his position as a banker. They are both serving the commonwealth, and both useful in their own way. I once overtook a man in the country, and he told me he had seen our "firewheel boats" at Tientsin, where he had been a merchant. I thought I had got hold of a big swell, and inquired where his offices were. He informed me he had no offices. He dealt in needles. He saw nothing to laugh at in the matter; it was an honorable occupation, and something to be proud of. In one of these narrow lanes we find the Tsung li Yamen, the Chinese Foreign Office. Inside the gate is a portal on which are four characters, meaning "Prosperity at home and abroad." The buildings inside are of the usual Chinese style of one story, with paper windows, the principal rooms facing south, all with brick floors. This is one reason why the Chinese have such thick soles to their boots. A Chinese room, to our western ideas, lacks comfort, as there are no chimneys in the houses; the fires are made in pots in the middle of the room, and though smokeless coal is used, there is a certain amount of fumes that are not at all pleasant. The fire is not so much for heating the room as for making water hot for tea, and they depend on their clothes for warmth in the winter. At this place there is a college, under foreign professors, for teaching the Chinese languages and science, the students being fed and paid a monthly salary to come and study.

Passing on, we go through the fore court of a prince, and pass the front door, not of his house, but of his courtyard, the houses are out of sight; they are a series of one story rooms, with paper windows and brick floors. The front hall that we are passing is a very large building, with stone lions on either side of the steps; it is the regular custom to have bronze or stone lions outside these large residences. The gardens inside are laid out very beautifully; nature is imitated in a miniature way with rock, water, and trees. If a Chinaman has only a few feet for a back yard, he will try and introduce some rocks and water. We arrive at length on one of the big streets, with its fine shops, many with carved and gilded fronts. The shops, so different from our idea of them, are all open in the front to the street, with no windows in which to exhibit their wares to tempt the money out of people's pockets. It is as well to know what is required before going into them. The shopkeepers are a hard working class, up with the sun, and the shops are swept ready for customers almost before it is well light. There is no Thursday closing, or Sunday either, and so far as I know, no grumbling; about the only holiday is New Year's Day, then all shops are shut. The streets, though wide, are much cumbered by booths and stalls, some of them quite substantial structures, others taken down at night; here gathered under an awning is a large audience seated on benches listening to a story teller, on the outside is a man with a huge teapot well wrapped up in cotton wool, as they do not possess any flannel, to keep the tea warm until he can sell it out at one cash a cup. Another man has a fire with an iron girdle on the top, on which he is cooking, in oil, little tasty smelling lots of mutton and onions. I may state I never saw dog's flesh offered for sale, or anything in the way of meat worse than a donkey. I have seen very poor people dragging away dogs, and have been told they would eat them; but that was because they could not get anything better, not from choice. But this is a very long subject, and I had better pass on.

Among other curious things we are sure to see is a bier arranged out on the street. Funerals are great institutions in Peking; in fact, these and weddings seem to be the only jolly times the poor folks have; they are both made a time of feasting, and, to us foreigners, one seems about as gay as the other. This bier is waiting for the coffin, the funeral taking place the day after the bier is erected in the street, when the coffin is placed on it; the whole structure is borne on the shoulders of sixty-four men, and carried to the grave; it is very heavy, and must weigh much more than a ton. Fancy erecting a structure like this in the middle of the Strand! The traffic has to go where it can. Beggars we are certain to see; I once photographed a group of them and gave them each one shilling; they grumbled at the little money, and accused me of wasting their time. As distances are great, it is as well to take a cab, of which we see many hundreds in the streets; we foreigners call them carts. It is just a box on wheels, without springs, covered on the top with a wooden framework, over which is stretched blue shirting; the wheels are very heavy, the axles, of hard wood three inches in diameter, stick out beyond the wheels about six inches. The driver sits on one side of the shafts, but, before he starts, he takes a brush out of a little bottle that hangs by the side, and oils the wheels; under his seat, under the cart, is a basket and a little tub, the one is a nose bag and the other is a tub to supply the animal with water. When the horse is feeding it is used to stand the basket on. The proper way is to get inside these carts and sit tailor fashion, but the rough roads and lack of springs cause us to alter our minds and sit like the driver, on the other side of the shafts; this is by no means comme il faut, and never adopted by any respectable Chinaman, but we think it better to withstand custom for the sake of moderate comfort. These vehicles have a blind that can be let down over the front, but it in no way keeps out the cold or dust. As Chinese etiquette demands that one gentleman shall not pass another if he knows him without dismounting if riding, or getting out of the cart if driving, and making a formal bow and greeting, the journey has many breaks and is necessarily slow. To get out of this greeting ceremony the blind is let down in the cart and the passengers pretend they are not there, and get on their journey as fast as they can.

By this time we have arrived at Legation Street. It runs parallel and near to the south wall of the city. The whole of the legations and the inspectorate of Chinese maritime customs are within an area of half a mile. They are nearly all situated in parks surrounded by high walls. There is nothing to be seen from the streets but the gates and walls, except the British legation, which has built several two storied houses; and the tops of these can be seen from some distance. The Russian legation is the oldest, having existed in Peking for over a hundred years. Near the legations are the principal government offices. Five of the six boards are on the east of the Imperial city, and one, the board of punishment, on the west. There is nothing particular to call attention to in these buildings, they are built in the usual Chinese style of one story and a large courtyard in front, with perhaps more than the usual quantity of dirt and dilapidation.

The board of punishment, called the "hsing pu," on the west, is the best known; it is the state prison, and cannot be visited by foreigners unless they stay, and I have never heard any one express a wish to do so. The late Sir Harry Parkes describes the horror he felt when he passed within its chained gate. Like the examination hall, there is a hole in the northwest corner of the wall through which the bodies of the unfortunates done to death are thrust. I do not think prisoners are actually executed within the walls; they are only tortured to death. There is a public execution ground outside in the Chinese city.

Following the canal by the front of the British legation brings us to the corner of the wall of the Imperial city. It is about six feet thick and twenty five feet high, and seven miles round; the top is roofed with yellow porcelain tiles. This is a characteristic of Peking. All the public buildings are covered with these glazed tiles, every dynasty having its own color, some green, some yellow. The present dynasty, which is the "ch'ing" or "pure," has adopted yellow. All the palace buildings are covered with tiles of this color. There is a moat inside the walls, crossed in various places by stone bridges. The city is entered by three gates, one in the east wall, one in the north wall, and one in the west wall. I have already spoken of another, the "great pure gate" in the south; but as that is not for common people, I do not notice it again. These gates are inside a large hall; they are not closed at night. As the Emperor transacts all state business very early in the morning, mandarins are constantly coming and going, and when lazy people get up to go to business about nine in the morning, crowds of these courtiers and their suites are to be seen hastening home, after their early audience with the Emperor. About half a mile inside these gates are the gates of the Forbidden city, something like the large gates in the big wall of the Tartar city. As that is very much forbidden ground, we pass on, and in the center of the city—still forbidden—is a hill about 300 feet high, said to be composed entirely of coal, for use in case of a siege. There are five pavilions on the top, that were built during the Ming dynasty. It was here that the last Emperor of the Ming dynasty, finding all was lost, hanged himself—the Chinese say on a crab apple tree—and the tree can be seen to this day in chains. I inquired if it was not foolish to put a tree in chains. They said, "No: the tree has sinned, and must be punished."

On the south of this coal hill is a broad moat that encircles the Forbidden city, and on the other side are the walls; they are two and a quarter miles round, guarded by numerous stations of bannermen. There are three gates into this city. No one but Chinamen that have official business and wear official hats are allowed to enter; no person, whatever his position, is allowed to drive, ride, or be carried in a chair inside this city—all dismount at the gates. According to the notions of the common folk, all here is gold and silver. They will tell you of gold and silver pillars, gold and silver roofs, gold and silver vases in which swim gold and silver fish. All this part of the city is just as it was left by the Mings in 1644. When the conquering Manchus swarmed in, they found a magnificent city and palaces all ready for them, uninjured and strong, which were apportioned among the victorious army for habitation. This army consisted not only of Manchus, but of Mongols and Chinese, and was divided into eight banners; thus they were called bannermen, and very few Chinese merchants were allowed to reside in the Tartar city. The Chinese, called "Min Jen," were obliged to live in the southern Chinese city. Partly by intermarrying among the banners of different nationalities, and, in much rarer cases, among the ordinary Chinese, the Manchu element has become almost absorbed, and the Manchu language, as a living language, has disappeared in Peking, though it is still used as the court language. The greater mass of the population strikes the observer who comes from the south as taller and stronger built, which shows the mixture of the Manchu blood. Until within the last fifty years the whole population of the Tartar city consisted of bannermen, but now there are many Chinese among them. These bannermen are the virtual army of Peking, and it costs the government £100,000 every month to keep them on starvation pay. They form the whole of the police, amounting to 12,000 men, most miserably clad. They are the firemen, and also keep the streets in repair. As a class, the bannermen are lazy and proud; as soldiers, there is the making of good men in them if they were properly trained; at present they are worse armed and trained than any soldier in China. Many are armed with bows and arrows. Skill in archery and great physical strength are deemed of more importance than any other attainments relating to war.

On the north side of the moat, not in the forbidden part, is the Temple "Ta-Hao-tien." It is used by the Emperor when any national circumstance demands prayer, such as want of rain or snow. It has three portals, one on the east, one on the south and one on the west. The Emperor enters by the southern one. They are made of wood, beautifully lacquered and painted. There are two houses with very complicated roofs, covered with yellow tiles, just inside. These would be used by the guard during the Emperor's visit.

The road runs right through the palace gardens, crossing a fine lake by a marble bridge. From here we get a peep at the inside. This is one of the most beautiful spots in the city. The lake, more than a mile long, in summer is covered with a mass of lotus, whose round leaves form a carpet of green, dotted with myriads of pink flowers as large as basins, which help to make a beautiful picture that any one could admire; the perfume from the flowers, wafted by the wind, can be smelt half across the city. In winter the lake is covered with ice as clear as crystal, on which the imperial family disport with sledges. On the banks of the lake are handsome summer houses and temples, beautiful groves and examples of the art of landscape gardening, in which the Chinese excel. The hill, which is an island, is capped by a marble dagoba. Here there is an altar to the originator of the silk manufactures and to the presiding genii of the silkworm; round it are mulberry trees. The Empress comes here annually to feed the silkworms; she thus sets an example of industry to the working women of the empire. The building to the right is a temple dating from the Mongol times. The high wall is overhung with the branches of the white pine, which only grows round Peking. It is now impossible to go on this bridge, as the Emperor Kuang-Ssu has ordered the road across it to be closed, and anyone now wishing to cross the city has to make a detour round the wall of the Imperial city.

On the southeast side of the palace is the "Tai-Miao," the Temple of Ancestors. It is the family temple of the Emperor, and more honored than any religious structure, except the Temple of Heaven. To be on the south, and also on the east of the palace, is the summit of honor.

In the street leading to the west gate is another celebrated temple, dating from the sixteenth century. It is called "Li tai-wang-Miao," dedicated to the kings and emperors of all dynasties, containing tablets inscribed with their names. It is an impressive sight, these simple tablets of men who once ruled this kingdom, standing here side by side, worshiped by their successors, that their spirits may bless the state. On our way we cannot help but notice wooden arches that span the street in various places. I think in these cases they are just for ornament, and seem to mark a locality; some of them are in the last stages of decay. The street lamps are most substantial structures; a wooden lantern, glazed with paper, standing on four legs. The illumination is not at all in proportion to the strength of the lamp. The light is obtained from a small clay saucer, with oil, in which is a small wick, and it just serves the purpose of preventing persons running into the lamp; as they are only lighted on moonlight nights, they may be credited with lighting the city.

Continuing our journey out of the north gate of the Imperial city, we come to a most substantial brick structure, 99 feet high, and about 50 feet square, with tunnels running through it in the form of a cross. This is the Drum Tower, containing a large drum, which is beaten in times of alarm, and to give the watches of the night. A little to the north of it is the Bell Tower, in which is hung one of the five bells which the Emperor Yung Lo (second emperor of the Ming dynasty) caused to be cast at the beginning of the fifteenth century. The bell weighs 120,000 lb., and is covered inside and out with 250,000 Chinese characters. This tower was built by the Emperor Ch'ien Lung of this dynasty, the bell having formerly been hung on an open scaffold.

There is a large Mohammedan population. All the sheep killed in the city are killed by Mohammedan butchers. There are also several mosques. Chinese historians say that the Emperor Ch'ien Lung built one for his favorite wife, who was a princess from a tribe of Turkestan.

In the northeast of the city is a most famous Buddhist temple, the Yung-Ho-Kung, or "Lamasary of Eternal Peace," where 1,500 Mongol and Tibetan priests study the dogmas of Buddhism, or spend their days in idleness, under the control of a Gegan or living Buddha. The rehearsal of the prayers and chants by so many men is very fine and impressive. They chant the prayers and drink porridge out of a pail. There is a wooden gilded idol of Mait re ya, the coming Buddha, 70 feet high. The priests in this temple are very rough, and though they are prepared to show visitors round and take their money, they will stand no nonsense; I mean they will not allow globe trotters to steal the little idols that line the wall in thousands. They reserve that privilege to themselves; they are most averse to photography, and several times I have been bundled out with all my kit, pretty roughly. The Mongols are of a different temperament to the Chinese; where the latter would put up with an amount of insult provided it paid, the Mongol would adopt the old English argument and punch your head. There is a Buddhist Bible in this temple, unabridged, complete in 400 volumes.

We often accuse the Chinese of doing things topsy-

turry, and, among other things, of putting on the roof of a house before they build the walls; this is a fact, and we pass a temple in which they are working on the roof before a brick is put to the walls. In building they do not trust to the walls for supporting the roof, they are used to stop up the sides; the roof is supported on posts which, in course of time, rot at the bottom and let it down.

Within a short distance is the Confucian temple, embowered in a grove of ancient cypress trees, said to be more than 1,000 years old; the building is a fine imposing structure, from 40 to 50 feet high, supported on thick teak pillars, brought from southwest China. In front is a broad and handsome terrace with balustrades in white marble; it is ascended on three sides by 17 marble steps. There are no idols in this place, simply tablets to Confucius and the other sages; the inscription is in Chinese and Manchu. All is simple and quiet here; the scene presents an impressive instance of the merited honor paid to the moral teachers of the people. Round the roof are hung handsome tablets in praise of Confucius; each Emperor presents one in token of veneration for the sage. Every inscription is different, and presents some aspect of his influence. He is called, "Of all born men the most unrivaled," "Equal with heaven and earth," and there are many such sentences in this strain. Here the Emperor or his representative worships the great sage twice a year. In front of this hall is a handsome portal in which are the celebrated stone drums; they are believed to date from the Chin dynasty, 200 years after Confucius, and to be, therefore, about 2,000 years old; as the characters were becoming illegible, the Emperor Ch'ien Lung had some new stones cut, and placed on the south side of the gateway. In front of them is the court of triennial examinations for the highest literary degree of the Chinese, "Chin Shih" (doctor of literature). A stone is here erected in commemoration of each examination, and the names and residences of all who have received this title are inscribed on them; the oldest are three still remaining of the Yuan dynasty, five centuries ago, and up to the present time the monuments are nearly complete.

Adjoining the Confucian temple is the Pi Yung Kung, or the Hall of the Classics; it is generally known as the Kuotze Chien. Besides the beautiful hall built by the Emperor Ch'ien Lung, in the center of a marble pond, there is a magnificent porcelain arch, covered with yellow tiles, and on each side of the place, in long cloisters, stand 200 upright stone monuments, engraved on both sides; which contain the complete text of the nine classics.

These are about the principal things to be seen inside the city of Peking.

I have endeavored this evening to give you a general opinion of what Peking is like. I have refrained as much as possible from entering into many details as it would be impossible, in one evening, to notice the many important places in the city. In an ancient city like Peking, with everything so strange to western ideas, all one sees naturally excites curiosity, and there is an abundance of facts connected with almost everything. I have told you only what I know to be true, or what has been related to me by the natives, and I have endeavored to verify as much as I could by photographs taken by myself, most of them by the collodion process. I am not asking you to consider them as works of art, as I have had to get many under great difficulties, and have only used them this evening to illustrate my subject, and make it easier for me to convey the ideas I wish to give you.

LICHENS.

LICHENS are familiar as brown or gray crust-like patches on rocks, old stumps, the trunks of trees, and even on the ground. Those on trees are frequently pendent, and are known as long moss or beard moss. Those on the ground frequently produce little cup-like structures bearing bright red tips. If we cut a thin section from one of the leaf-like forms and study it under a microscope, we shall find that in the central portion there will be seen a number of green, blue-green or brown-green cells (gonidia), either separated or arranged in groups. Surrounding these cells, both above and below, is an interwoven mat of long, slender, colorless cells (hyphæ). The hyphæ may be simple or branched and divided by partitions into longer or shorter segments. The greenish or bluish cells in the center are algæ that have been seized upon and enveloped by a parasitic fungus, the two forming together the composite organism known as the lichen.

The algæ which enter into the composition of lichens are all fresh water plants, living normally either in ponds, slow-moving streams, on damp walls, tree trunks, or even in moist places on the ground. This class of plants may be typified by the waving, bright green, hair-like growths so often observed in ponds, quiet streams, or in and about watering troughs. Besides these, which consist of a chain of short cells placed end to end, there are numerous others living in the same places that during their whole life consist of single, simple, more or less spherical cells. They are so very minute as to be singly invisible to the naked eye, but in masses produce a characteristic green color. One of the simple one-celled forms is well known as producing the bright green coloring of tree trunks, old fences, the sides of brick houses and brick walks, which comes out so strikingly on damp or rainy days. The kinds of algæ made use of by the fungus are usually simple celled, but the slender, chain-like forms are also sometimes seized upon. The hyphæ of the lichen fungus embrace the algal cells, and the two elements together compose a structure of definite form.

The fungus element of the lichen is the only one which produces reproductive bodies. These are single-celled bodies called spores, and may be likened to the seeds of flowering plants. It was found that when these spores germinated they were unable to develop beyond a certain stage unless they were supplied with a number of algal cells. A distinguished German investigator was able to produce in the laboratory a well-known species of lichen by combining the proper fungus and algal cells, and it is said that three species have been manufactured artificially in this way.

It would hardly be expected that such humble plants could play a very important role as a food supply for man, yet they do have an importance and value. In Arctic lands, where other kinds of vegetation are scanty or absent, there is usually an abundance of lichens. "Iceland moss" is a well-known lichen found abundantly in Iceland. It is gathered in large quantities by the natives, deprived of its bitterness by boiling in water, and then dried and reduced to powder. It is usually used with flour and milk or made into cakes, and in times of great scarcity it forms almost the only article of food. Another edible lichen is known as "rock tripe." It also inhabits Arctic countries, growing in crusty patches on rocks. It is usually boiled and eaten only when other things fail. But perhaps the most interesting of all the esculent lichens is that known as the "manna lichen," which in times of famine has served as food for both man and cattle in the arid steppes from Algeria to Tartary. It grows in layers from three to six inches thick, and over vast areas it is found in the form of small irregular lumps of grayish or white color. The "reindeer moss," so abundant in cold countries, especially in Lapland, is also a lichen and furnishes almost the entire food of the reindeer during the winter months. Lichens supply a number of valuable dyes—archil, a rich purple dye; cudbear, formerly much used by the peasants of Northern Europe to give a scarlet or purple color to woolen clothes; litmus, an indigo blue coloring matter much used in chemistry; and several more or less valuable yellow dyes are afforded by various lichens, as well as a number of red, purple or brown dyes.—F. H. Knowlton, Ph.D., in Popular Science News.

[FROM KNOWLEDGE.]

NEW ANIMALS FROM MADAGASCAR.

By R. LYDEKKER, B.A.Cantab., F.R.S.

AT a time when public attention is directed to Madagascar as the scene of an impending war, our readers will doubtless be glad to hear something of certain new discoveries which have recently thrown much additional light on the past zoological history of this most interesting and remarkable island. Probably many of them are aware that the Malagasy fauna differs most strikingly from that of the African mainland, in spite of the small extent of sea by which the two areas are separated from one another, and it is evident that although the ancestors of the majority of the animals now inhabiting Madagascar obtained an entrance by means of a former land connection with East Africa, yet the date of that connection must have been extremely remote. At the present day, Africa south of the Sahara desert is specially characterized by the numbers of species of antelopes of various genera which swarm on its open plains, as well as by giraffes, zebras, rhinoceroses, elephants, hippopotami, wart hogs, bush pigs, lions, leopards and various other large cats, baboons, man-like apes and ostriches. On the other hand, with the exception of one living species of bush pig and a fossil hippopotamus, not a single representative of any one of these groups is met with in the adjacent island; and, as has been pointed out by Mr. Wallace, it would appear quite probable that both the pig and the hippopotamus may have obtained an entrance by being carried across the channel—possibly at a time when it was somewhat less broad than at present. In place of the animals mentioned above, we find in Madagascar numbers of lemurs, all belonging to genera and species distinct from those inhabiting either Africa or India, and so numerous that they form nearly one-half of the whole mammalian population of the island.

Civet and ichneumon like carnivores, likewise pertaining to peculiar genera, are also abundant, and these seem to affiliate the fauna to Africa rather than to Asia, seeing that such animals are more numerously represented in the former than in the latter continent. Among the most remarkable of these civet like creatures is the so-called fossa (Cryptoprocta), which has a uniformly sandy coat, and may be compared in point of size to a short legged lynx, this creature differing so markedly from all its allies as to be entitled to represent a distinct subfamily by itself. It has, indeed, been considered that the fossa is closely allied to certain extinct carnivores from the lower Tertiary deposits of Southern Europe, and, although some writers are disinclined to accept the relationship, it is not improbable that the theory is well founded.

One of the most remarkable features connected with the mammalian fauna of the island is the circumstance that the family of the insectivorous order known as the Centetidæ is represented elsewhere only in the West Indies, although the generic forms inhabiting the two areas are distinct.

Another apparent indication of American affinities is afforded by the presence of iguana lizards (Iguanidæ), which are now unknown in any other part of the Old World except the Fiji and Friendly Islands. Iguanas are, however, found in a fossil state in the lower Tertiaries of Europe, and it therefore seems probable that their present anomalous geographical distribution may be explained by dispersal from a common northern center, although it has been thought to indicate a connection between Madagascar and South America.

If this be so, a similar explanation will hold good in the case of the Centetidæ, although, in spite of statements to the contrary, these have not yet been discovered in a fossil state. It will likewise serve with regard to the occurrence of an identical genus of fresh water tortoises in Madagascar and South America, and also of certain resemblances between Malagasy and Australian reptiles.

With regard to the former connection between Madagascar and the mainland, the occurrence of marine strata of Eocene age in Egypt and other parts of Northern Africa proves that at the period of their deposition the portion of the latter continent lying to the south of the Sahara was cut off from Europe and Asia by an arm of the sea, so as to form an island continent, in the same way as was South America during some part of the Tertiary epoch.

Probably, soon after this, or in the upper Eocene period, this Ethiopian island, as it may be called, of which Madagascar evidently formed a part, was temporarily connected with the northern land when it received its fauna of civets, lemurs and insectivores, which a subsequent disconnection allowed to develop without persecution from higher forms of later age. During this time Madagascar became separated, and in the upper Miocene or lower Pliocene age Southern Africa once more became connected with Europe and Asia, which (like North America) were then the home of the various large mammals mentioned above, as well as ostriches. This connection thus allowed a later and more highly organized fauna to sweep over Asia, where it found a free field to develop at the expense of creatures of a lower type.

On the other hand, the isolation of Madagascar allowed the more primitive fauna to remain there unmolested, and to attain a richness of development which was never reached elsewhere. As to the date when the ancestors of the gigantic flightless Malagasy birds known as Æpyornis obtained entrance into the island, further evidence seems necessary, as we are not at present aware that any nearly allied forms existed in the European Eocene, unless, indeed, we are to look upon Gastornis of the London Clay and corresponding strata of the Continent in that light.

The giant tortoises, whose remains are found in the superficial deposits of Madagascar, belong to a group which was widely spread over Europe in Tertiary times, and their ancestors may consequently have entered with the primitive insectivores, civets and lemurs. From Madagascar, according to the views of Mr. Wallace, the adjacent islands, which, in comparison, are exceedingly poor in mammals, received such forms of life as were capable of crossing the intervening sea; while, in their turn, they formed the stepping stones by means of which the larger island was populated by such Indian birds and insects as had been able to reach them.

At the present day, the existing lemurs of Madagascar may be compared in point of size to small or medium sized monkeys, the largest of them—the short tailed indri—not measuring much more than a yard in length. The investigations recently carried on by various intrepid explorers in the island have, however, revealed the fact that up to a very late period Madagascar was the home of a lemur vastly exceeding in size any of the existing representatives of the group, and which in this respect may be compared to the great West African baboon known as the mandril. This giant lemur (Megaladapis, as it is called by its describer, Dr. Forsyth Major) is known by the somewhat imperfect skull and lower jaw, which are about three times the dimensions of those of the indri. The interest of this animal is, however, by no means confined to its comparatively gigantic proportions, since, while its skull and teeth conform in their general structural features to those of the existing members of the group, they are specially modified in a manner altogether peculiar.

The most striking peculiarity connected with the skull is the extreme slenderness of the hinder portion containing the brain in comparison with the great elongation of the face; the latter seeming out of all proportion to the former. In this respect, indeed, the skull presents a curious resemblance to the so-called dog faced baboons of Africa; as it also does in the strongly marked ridges it bears for the attachment of powerful muscles. Such resemblances, however, it is almost needless to observe, are merely superficial, and must, by no means, be taken as indicative of any genetic relationship between the two groups; and if a young skull were forthcoming, it is probable that we should find this much less unlike ordinary lemurs.

Another peculiarity of the giant lemur is to be found in the more lateral position and wider separation of the sockets of the eyes, which are also relatively smaller than in existing forms, thus indicating that the habits of the animal were less completely nocturnal than those of the latter. The molar teeth of the upper jaw are characterized by the presence of only three tubercles on the crown, owing to the fusion of the two inner ones of the four columned molars of ordinary lemurs; a few of the smaller existing species having, however, teeth of a nearly similar type.

Although in the type skull the front teeth are wanting, the form of their sockets shows that they must have been very similar in general form to those of living lemurs. In many respects the skull shows a marked resemblance to that of the European Tertiary lemur known as Adipis, a feature of especial interest in regard to what we have said as to the origin of the Malagasy fauna from that of the Eocene period in Europe.

The remains of the giant lemur were discovered in the great marsh of Ambolisatra, and their slightly mineralized condition indicates their comparatively recent age. Indeed, there is but little doubt that the creature has been killed off within the human period, and in his history of Madagascar, published in 1658, De Flacourt writes in the following terms of an animal then inhabiting the island, which, if not actually the giant lemur, would appear to have been a closely allied form. He writes that "Trétrétrétré ou Tratratratra, c'est un animal gros comme un veau de deux ans qui a la tête ronde et une face d'homme; les pieds de devant comme un singe et les pieds de derrière aussi. Il a le poil frisoté, la queue courte et les oreilles comme celles d'un homme. Il resemble au Tanache d'escrit (sic) par Ambroise Paré. Il s'en est vu un proche l'étang de Lipomani, aux environs duquel est son repaire. C'est un animal fort solitaire, les gens du pays en ont grand peur et s'enfuient de lui comme lui aussi d'eux." With the exception of the rounded head and the size (which is doubtless exaggerated), this description accords remarkably with the giant lemur, and when the head was covered with fur it is probable that it would appear much less elongated than does the bare skull.

The giant lemur is, however, not the sole extinct member of the group recently brought to light, since the hinder part of a skull indicates another large species belonging to a new genus, but apparently allied to the existing Malagasy lemurs known as Hapalemur.

Although the extinct Malagasy hippopotamus (H. lemerlei) was named as far back as 1868, it is only recently that we have become fully acquainted with its affinities. In spite of its smaller size, it appears to have been nearly allied to the living African species. As it is somewhat difficult to believe that a hippopotamus and a bush pig could have swum a channel of the width of that separating Madagascar from the mainland, it is not improbable that in the latter part of the Tertiary period this was much narrower—perhaps not more than ten miles in width.

From the same marsh of Ambolisatra which yielded

the remains of the giant lemur have been obtained the eggs and bones of the gigantic Malagasy birds known as Æpyornis. From the enormous dimensions of the eggs (one of which was recently sold in London for upward of sixty-seven pounds), it was evident that some of these birds must have been of gigantic proportions, but till lately bones had not been obtained of commensurate size. Certain limb bones recently received by Mr. Walter Rothschild enable us, however, to realize the gigantic stature attained by the largest species of these birds—a leg bone or tibia measuring no less than thirty-two inches in total length.

Probably some of the species of these giant flightless birds lived within the human period, although we have no historical evidence to this effect. The same is the case with regard to the large land tortoises of Madagascar, two very fine shells of which have been acquired within the last few years.

From the foregoing observations it will be gathered that the new discoveries regarding the latest extinct animals of Madagascar merely serve to amplify our knowledge of the fauna, and in nowise invalidate the conclusions previously drawn as to its past history. Investigations carried on among the older rocks have, on the other hand, thrown an entirely new light on the state of the island during the secondary epoch of geological history, and have likewise a very important bearing on the evolution of the surface of the earth as a whole. For many years it has been known that marine rocks of Jurassic and Cretaceous age occur on the west side of the island, but there does not appear to have been any decisive evidence that during these epochs Madagascar itself was in existence. The recent discovery of remains of land reptiles corresponding very closely with some of those from the Jurassic rocks of Europe enables us now to say with confidence that land here existed in this region from at least the date of the earlier of the two epochs in question. The first of these two reptiles is known by portions of the skull and jaws, which prove that it belonged to a European Jurassic genus of long-snouted primitive crocodiles, to which the name of Steneosaurus has been applied, this genus having been hitherto unknown elsewhere than in Europe. Still more interesting are a number of gigantic vertebræ and limb bones, described in a paper just read by the writer before the Geological Society. If our readers can recall an article entitled, "Giant Land Reptiles," published some years ago in Knowledge,* they may remember that the so-called dinosaurs are divided into three main groups, one of which has been designated by the name of sauropodous, or lizard-footed. These enormous reptiles, which are the largest known to science, and are well represented in the Jurassic and Cretaceous rocks both of Europe and the United States, are specially characterized by the presence of large cavities on each side of the vertebræ of the neck and trunk, such cavities generally communicating with honeycomb-like excavations in the body of the bone itself. The Malagasy representative of the group, which appears to have been fully as large as its European cousins, belongs to a hitherto very imperfectly known genus, first described from the Jurassic rocks of England, under the name of Bothriospondylus. Thanks to the new specimens, we are now enabled to state that this genus differs from the others of the group in that the lateral cavities of the vertebræ had no connection with any honeycombing of the interior, which was, in fact, solid.

Interesting as is this circumstance, it fades into insignificance in comparison with the light thrown by these and other representatives of the same group on the past history of the globe in general.

We have said that sauropodous dinosaurs have long been known from Europe and North America, and some years ago the writer had the good fortune to make known the occurrence of a member of the same group in the Cretaceous rocks of India, under the name of Titanosaurus. The same genus was subsequently identified from the corresponding rocks of England, and only last year the writer was enabled to describe the remains of yet another species from the approximately corresponding deposits of Patagonia.

We have thus evidence that gigantic sauropodous dinosaurs ranged over Europe, India, Madagascar and North and South America during the Jurassic and Cretaceous periods; one of the genera being common to such widely separated areas as Madagascar and England, and a second to India, England and South America, while several probably ranged over Europe and the United States. It is further evident that when the Bothriospondylus flourished in Madagascar that island was joined to Africa, as it is most unlikely that such a gigantic animal could have been restricted to such a comparatively small area as the former; and we may accordingly assume that the group then ranged over Africa, which we know from other evidence to have been land during the epoch in question. Accordingly, we conclude that during Jurassic and early Cretaceous times almost the entire world was inhabited by closely allied gigantic land reptiles, and thus not only that its fauna was practically similar, but that all the great continents were intimately connected with one another, and that the insulation of large areas like peninsular India, Africa south of the Sahara, and South America, which formed such a remarkable feature of early Tertiary geography, was then quite unknown. Since Australia, at or about the same epoch, was apparently more or less closely connected with Asia, we conclude that both the evolution of distinct regional faunas and the separation of large southern island continents (now, for the most part, reunited with more northern lands) took place during the Tertiary period.

We may mention, in conclusion, that geologically Madagascar may be roughly divided into two distinct areas by a north and south bisecting line. To the right, or east, of this line, the country is composed of granite, gneiss, basalt and other rocks of igneous origin; while to the left or western side, it consists of sedimentary strata ranging in age from the Jurassic to the Tertiary epoch. The old crystalline area may very probably have existed as land ever since the period when the giant dinosaurs ranged over its surface; and it may be suggested that the Jurassic and Cretaceous sea separating this old land from the continent was merely a gulf, and that either the southern or northern extremity of Madagascar was then in union with the mainland.

* Republished in "Forms and Phases of Animal Life," by the present author.

THE FUNDAMENTAL DIFFERENCE BETWEEN PLANTS AND ANIMALS.*

To the advanced student, as to the investigator, the question of a definite and accurate distinction by which all true plants can be distinguished from all true animals is a question of minor interest. To the beginning student the question, on the contrary, is a pressing one for which the answer is urgently claimed. Thus I am led to believe that the definition given below, though it cannot add anything essential to the conceptions of investigators, will nevertheless prove valuable to teachers of biology.

The usual method of drawing a contrast between the animal and vegetable kingdoms, for the purpose of establishing some sort of definition of the two in students' minds, is to leave out of consideration the lower forms, and to take into consideration only the higher forms, on the one side plants with chlorophyl, on the other the multicellular animals or so-called Metazoa. It is then easy to establish a difference in the physiological nutritive processes, emphasizing the synthetic processes, particularly the power of bringing free nitrogen into combinations on the part of plants and the absence of the synthetic process among animals. It is much to be regretted that this method of defining animals and plants has been and still is very widely used, for it leads to inevitable perplexity, because the next thing almost which the student must learn is that the distinction does not hold true. On the one hand, he learns that among plants there are many forms without chlorophyl and that these cannot bring nitrogen into combination and must secure proteid food. On the other hand, he learns that among animals numerous synthetic processes occur, and if he takes up the study of medical physiology, he learns many instances of synthetic chemical work on the part of the mammalian body. Dr. F. Pfaff has kindly indicated to me two striking instances of synthesis in the mammalian body, first, the formation of glycuronic acid after the administration of camphor or turpentine, and second, the formation of hippuric acid after the administration of benzoine.

Another distinction often drawn between animals and plants is that of the presence or absence respectively of internal digestive organs. But this again soon leaves the student in the lurch, for the first amœba he examines knocks that distinction out of the ring.

We may, however, I think, rightly define the two primary divisions of the living world thus:

Animals are organisms which take part of their food in the form of concrete particles, which are lodged in the cell protoplasm by the activity of the protoplasm itself.

Plants are organisms which obtain all their food in either the liquid or gaseous form by osmosis (diffusion).

There are certain facts which appear to invalidate these definitions. The most important of such facts, so far as known to me, is afforded by the Myxomycetes, which, as well known, while in the plasmodium stage of their life cycle, take solid particles of food very much after amœba fashion. Through the kindness of Professors W. G. Farlow and G. L. Goodale, I have learned that there are no other plants which at the present time are known to take solid food at any stage. I understand also that botanists are by no means agreed to accept the Myxomycetes as veritable plants. One cannot but ask, Have we not here organisms which connect the two kingdoms? Certainly, in using the above definitions in teaching, it will always be easy to specify the one exception offered by the Myxomycetes and still leave a clear and available conception in the student's mind

Other facts which stand in the way of strictly upholding the two definitions are encountered among animal parasites. For example, a tape worm in the intestine does not apparently take up any solid food, but is nourished by absorption through the surface of its body of food material in solution. But in these cases we have evidently secondary modifications due to the parasitic life, and in the near relatives of the tape worms, the trematods and planarians, solid food is taken up. It is to be remarked, too, that it is possible, though perhaps not probable, that even tape worms will be found on more careful study to take up solid food.

The extent to which it has now been demonstrated that animals take up food in the form of discrete solid particles is not realized generally. The process has been observed with varying degrees of accuracy in the entodermal cells of the digestive tract of hydroids, ctenophores, planarians, trematods, annelids, crustacea, insects, amphibia, and mammals, and probably in other forms, which have not come to my notice in this regard. There is here offered a rare opportunity for a valuable research, by making a comparative study of the absorption of solid food. That the protozoa take up particles by means of their pseudopodia is certainly one of the most familiar and most betaught facts of elementary biology

I believe that we can also safely teach that the absorption of solid particles of food is to be considered one of the most essential factors in determining the evolution of the animal kingdom. The plant receives its food passively by absorption, and the evolution of the plant world has been dominated by the tendency to increase the external surfaces—to make leaves and roots. The animal, on the contrary, has to obtain at least the solid part of its food by its own active exertions, and to the effects—through natural selection—of the active struggle to secure food we may, I think, safely attribute a large part of the evolution of locomotor nervous and sensory systems of animals. That it has been the only factor cannot be asserted, of course, for a moment, but it is presumably not going too far in speculative conclusions to look upon it as the most important single factor. An equally important role must be attributed to the taking of solid food in connection with the evolution of digestive organs, which are cavities which hold food material until it is absorbed by the cellular walls of the cavities. Indeed, we may expect to find that the entodermal cavity had originally no digestive function whatsoever, but was merely a receptacle to retain the food while the surrounding entodermal cells swallowed it at leisure.

With these speculations I will close, adding only that the speculations have in themselves little value, their only value being to suggest lines of research which appear promising. The sober naturalist avoids the infernal dipsomania for sheer speculation, and in this article I have already yielded sufficiently to the temptation.

CHARLES S. MINOT.
Harvard University.

* Read before the American Society of Morphologists at Baltimore, December, 1894.—Science.

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